Universität Basel

Wirtschaftswissenschaftliche Fakultät

WWZ forum

June 2020

The Effect of Demographic Change on the Swiss Labor Market: The Role of Participation Rates

WWZ Working Paper 2020/10

Manuel Buchmann

Universität Basel
Peter Merian-Weg 6
4052 Basel, Switzerland
wwz.unibas.ch

Corresponding Author:
Manuel Buchmann
manuel.buchmann@unibas.ch

The Effect of Demographic Change on the Swiss Labor Market: The Role of Participation Rates

Manuel Buchmann*

June 22, 2020

Abstract

The ongoing demographic change is expected to negatively affect the effective labor supply of various developed countries. In order to counteract these developments, many suggested policy measures target the participation rate of women and old workers. In this paper, I develop a multi-sectoral CGE-OLG model where workers of different ages and skills are assumed to be imperfect substitutes and calibrate it to the Swiss economy. I use this model to evaluate the effects of the demographic change on the Swiss labor market and the potential of reforms targeting different participation rates. I find that a yearly decrease of old workers' preference towards leisure by 2% between 2022 and 2030 yields macroeconomic results that are comparable to an increase in the statutory retirement age by 2 years. While the increase of the retirement age succeeds in increasing net income by more than both participation rate increases, it also leads to an increase in wage levels and thereby labor shortages. This result highlights the importance of reducing scarcity on the labor markets for macroeconomic performance and shows the potential of reforms targeting labor market participation.

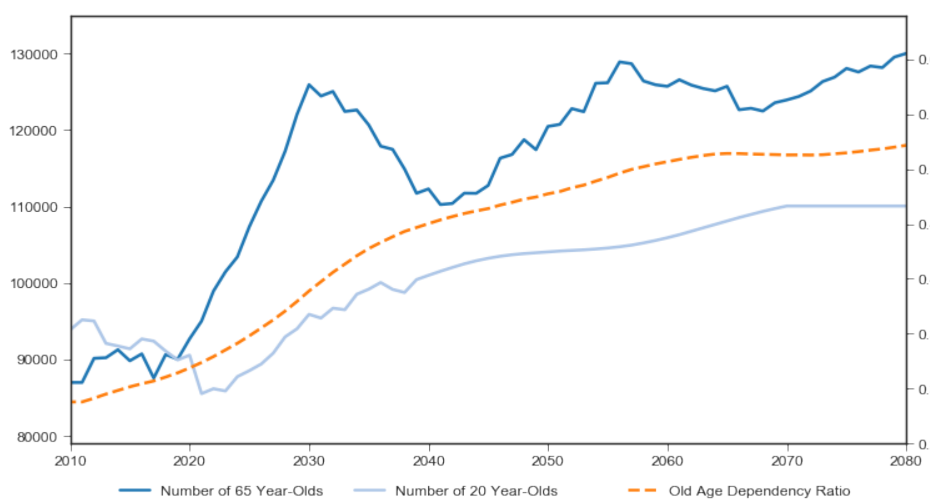
JEL Classification: D58, E24, E66, J11, J21, J26
Keywords: overlapping generations, demographic change, participation rates, switzerland

*This study is funded by the Swiss National Science Foundation (SNSF) under project No. 169532 "Consequences of the Demographic Change for the Swiss Labour Market". I thank Marcel Mérette, Patrick Georges and Conny Wunsch for their guidance and helpful comments.

1 Introduction

Population aging is an issue that needs to be addressed by public policy in most industrialized countries. For example, in Switzerland the old age dependency ratio, i.e. the ratio of the retired to the working age population, is expected to increase from 31.1% in 2020 to 39.6% in 2030 and further increase up to almost 50% by 2050. As the baby-boomer generation retires in the coming years, the country will experience a drastic reduction of the labor force. To illustrate this shock, Figure 1 shows the projected number of 20- and 65-year olds, i.e. an approximation of the number of potential domestic workers entering and leaving the labor market, as well as the projected old age dependency ratio. For the whole observation period after the year 2020, the number of 65-year-olds exceeds the number of 20-year-olds, meaning that Switzerland is relying solely on foreign workers to keep the labor force constant. Barring fundamental changes of production technologies (such as for example a rapid increase in the use of robotics), this is bound to lead to massive labor shortages, especially due to similar demographic trends in all geographically nearby countries. In order to temper the effects of the demographic transition, the government can attempt to increase the labor force participation rate of the working age population, raise the statutory retirement age, increase net immigration or, in the longer term, increase fertility. In this paper, I evaluate and compare the effectiveness of possible reforms targeting the supply of labor in Switzerland with respect to labor shortages but also general economic performance.

Figure 1: Demographic Trends in Switzerland



Note: Model projections based on reference scenario of the official projections by the Swiss Statistical Office Federal Statistical Office (2020).

Due to their generally lower participation rates, in particular women and older workers are potential targets for participation rate increases. On average, women start reducing their labor supply around the age of 28, mainly due to pregnancy and child rearing. A typical reform targeting the participation rate of women would therefore improve childcare assistance. Old workers decrease their labor supply mainly due to health issues or early retirement schemes. Making such schemes relatively less attractive or improving working conditions could therefore increase the labor supply of old workers. However, the evaluation of potential macroeconomic effects of such reforms is not straight-forward. During the demographic transition, many forces affect the choice of an individual's labor supply. As the pension system becomes less sustainable, higher savings or contributions to a pay-as you-go pension are required to secure a post-retirement income. At the same time, wages are expected to increase as labor becomes more scarce. However relative wages for old workers might decrease as old workers become relatively more abundant. The net effect on labor supply of workers of different ages is not clear even without taking into consideration possible policies targeting the labor supply.

In order to address this issue I develop a computable general equilibrium model with overlapping generations and calibrate it to Switzerland. This allows me to evaluate the consequences of the demographic transition on the Swiss labor market in a general equilibrium context. It also allows me to impose different reforms targeting the labor supply of different groups, such as women, old workers or migrants, and compare the macroeconomic effects of such a reform to other potential measures, such as an increase in fertility or the retirement age. To allow for a detailed analysis of distributional effects, the model is disaggregated into 79 generations (representing ages 20-99) and four skill levels on the household side, whereas firms distinguish between workers of the four skill levels and four age groups, i.e. young workers, middle-aged workers, old workers and workers above the statutory retirement age. This imperfect substitutability between age groups is based on a diverse range of evidence (see e.g. Hamermesh, 2001; Card and Lemieux, 2001; Buchmann, 2020; Mérette, 2007) and allows for a more realistic modeling of participation rates over the life cycle during the demographic transition. Additionally, the model is disaggregated into eight sectors. Households imperfectly substitute their labor supply between the sectors. Combined with the skill levels this allows for an approximation of occupation- and sector-specific labor shortages. It also enables an evaluation of distributional effects of different policies on a sectoral level.

This paper contributes to the long list of OLG models in the style of Auerbach and Kotlikoff (1987). Some of the most prominent examples include, among others, Altig et al. (2001), De Nardi et al. (1999) or Kotlikoff et al. (2007). For an extensive overview of this literature see Fehr et al. (2013). Most of these models focus on fiscal reforms or reforms of pension and social security systems. In this paper, I focus on the labor market instead. In this respect, I follow a growing strand of the literature such as for example Börsch-Supan (2003), Fougère et al. (2007) or Lisenkova et al. (2013). The model presented in this paper partially builds on Fougère et al. (2007) who develop a model which is disaggregated into seven generations, 14 sectors, three types of labor, ten occupational groups and five qualification levels and use this model to analyze the effects of population aging and its induced changes in final-demand on the sectoral composition of the Canadian economy. Their results highlight the growing importance of health services and the need for the wages in that sector to increase to avoid labor shortages. Mérette (2007) suggests the introduction of imperfect substitutability between age groups into OLG modeling. His results show how age-specific wages can lead to interesting incentives concerning early retirement. This idea is also picked up in the model presented here.

The OLG literature regarding Switzerland is relatively sparse. Müller et al. (2003) develop the OLG model SWISSOLG to evaluate alternative funding schemes for the Swiss pay-as-you-go (PAYG) pension scheme. In Müller et al. (2006) SWISSOLG is extended to analyze fiscal reforms. Bütler (2000) develops an OLG model with exogenous factor prices in order to evaluate the political feasibility of different pension reforms in Switzerland. Keuschnigg et al. (2011) develop a Blanchard (1985) style OLG model of the Swiss economy with a detailed labor market component, including search frictions. They use the model to evaluate the potential of policy reforms such as an increase in the retirement age or a reform of the pension system. Hauser et al. (2020) develop an OLG model in the Auerbach and Kotlikoff (1987) tradition and evaluate the effects of demographic change on the growth of the Swiss economy. They consider different forecast scenarios which also include scenarios with an increased participation rate of women and old workers, both of which are among the most positive scenarios considered, in terms of GDP per capita.

As to my knowledge, apart from Hauser et al. (2020), at the time of writing this paper there exist no major CGE-OLG models which explicitly analyze the macroeconomic effects of successful labor market participation reforms. Therefore, this papers' main contribution is the introduction of such a reform into academic OLG modeling. Furthermore, the paper contributes to the literature on labor market effects of demographic change by introducing imperfect substitutability across age groups and it contributes to the small but growing literature of Swiss OLG models by introducing a sectoral dimension and making use of the most recent data and forecasts.

The results of my model show that demographic change will negatively affect the Swiss economy, especially after 2030. GDP per capita is shrinking by 3.5% until 2070 and contribution rates to the pension system will have to almost double from 8.6% to 14.9% to keep the pension system sustainable at current levels. Due to different consumption preferences of older households, the relative importance of the health sector will increase from 5.9% of GDP to 6.3% of GDP, while the importance of the construction sector decreases from 6.8% to 6%. Almost all sectors are expected to experience noticeable labor shortages, especially for young and middle aged workers. This is manifested by wage rate increases of up to 20%. The health sector is particularly affected by these wage increases.

I implement positive participation rate shocks by gradually decreasing the preference towards leisure in some consumers' utility functions. I find that, in terms of GDP per capita, an annual decrease of this parameter by 2% for workers aged 50-64 between the years of 2022 and 2030 is roughly equivalent to an immediate and permanent increase of the statutory retirement age by 2 years and more efficient than realistic increases in net immigration or fertility rates. This adjustment corresponds to a total increase in full-time-equivalent participation rates by three to ten percentage points, depending on the exact age of the household. A corresponding participation rate increase for women yields marginally worse, but still very similar outcomes. Both increases of participation rates result in a reduction of wages, indicating a reduction of labor shortages. In terms of the sustainability of the pension system and consumers' disposable incomes, an increase in the retirement age is still much preferable. In this respect, it is even more striking that the participation rate reforms achieve similar results in terms of GDP per capita. These results highlight the potential of reforms targeting participation rates and the importance of reducing labor shortages.

The remainder of this paper is structured as follows. In Section 2 I briefly introduce the most important components of the model. In Section 3 I introduce the data sources and explain the calibration process. In Section 4 I present and then compare the simulation results of the baseline scenario, as well as the participation rate and retirement age reforms. In Section 5 I analyze the sensitivity of my results with respect to assumed parameters as well as alternative demographic scenarios. Finally, Section 6 concludes.

2 The Model

2.1 Producers

The model is disaggregated into 8 sectors s. Firms use a fixed share of intermediate inputs I which are combined with a Cobb-Douglas combination of labor L and capital K to produce output Y. Production technologies are therefore represented by the following production function:

$$Y_{s,t} = \frac{A_{s,t}}{1-\alpha_s^I} K_{s,t}^{\alpha_s^K} L_{s,t}^{1-\alpha_s^K}, \tag{1}$$

where A is total factor productivity, α^I is the fixed share of intermediate inputs and α^K is the Cobb-Douglas-parameter for capital. Labor is further disaggregated into 4 skill levels q[1], determined by a CES function:

$$L_{s,t} = \left(\sum_q \alpha^Q_{s,q} (L^Q_{s,q,t})^{\frac{\sigma^Q_s - 1}{\sigma^Q_s}} \right)^{\frac{\sigma^Q_s}{\sigma^Q_s - 1}}, \tag{2}$$

where σ^Q is the elasticity of substitution between differently skilled labor and α^Q is the firms preference parameter for labor with qualification Q. Skill-specific labor supply is further disaggregated into age-group-specific labor supply L^{AQ}:

$$L^Q_{s,q,t} = \left(\sum_a \alpha^A_{a,s,q} (L^{AQ}_{a,s,q,t})^{\frac{\sigma^A_s - 1}{\sigma^A_s}} \right)^{\frac{\sigma^A_s}{\sigma^A_s - 1}}, \tag{3}$$

where σ^A is the elasticity of substitution between labor from different age groups and α^A is the firms preference parameter for labor from different age groups.

2.2 Consumers

The model contains 79 overlapping generations g, where each generation corresponds to one year of age. Consumers are economically born at age 20. Every period, they face a chance of dying, defined by the survival rate S. At the age of 99 they die with certainty. I do not assume a bequest motive, however, as households die unexpectedly their remaining savings B are redistributed to all other households in the form of unplanned bequests $\mathcal{U}$. As in Imrohoroglu (1998), I assume that unplanned bequests are redistributed equally to all remaining households in a lump-sum fashion. Consumers are further disaggregated into 4 skill levels q. As is common in the literature, lifetime utility is assumed to be a time-separable CES function, such that in every period, consumers maximize their utility over consumption C and leisure ℓ. Expected lifetime utility is given by:

$$E_t\left[U_q\right] = \sum_{i=0}^{79} \left\{ \frac{1}{(1+\gamma)^i} \left(\prod_{k=0}^{k=i} S_{g+k,t+k} \right) u(C_{q,g,t}, \ell_{q,g,t}) \right\}, \tag{4}$$

where γ is the rate of time preference which is assumed to be identical across all households. One-period utility $u(C,\ell)$ is given by:

$$u(C_{q,g,t}, \ell_{q,g,t}) = \frac{1}{1-\frac{1}{\rho}} \left(C_{q,g,t}^{1-\frac{1}{\theta}} + \alpha_{q,g,t} \ell_{q,g,t}^{1-\frac{1}{\theta}} \right)^{\frac{1-\frac{1}{\rho}}{1-\frac{1}{\theta}}}, \tag{5}$$

where ρ is the intertemporal elasticity of substitution, θ is the intratemporal elasticity of substitution and α is the utility weight on leisure.

[1] The choice of distinguishing between four levels of skill is based on Buchmann (2020).

The households' labor income ψ is defined as follows:

$$\psi_{q,g,t} = w_{q,a,t}\xi_{q,a,t}\varepsilon_{q,g,t}(1 - \ell_{q,g,t}), \tag{6}$$

where w is the age-group specific sectorally aggregated wage rate, ξ is an age group and qualification level specific time endowment parameter, ε is an age and qualification level efficiency parameter, and ℓ is the share of time devoted to leisure (i.e. $1 - \ell$ corresponds to the full-time-equivalent participation rate).

The households' intertemporal budget constraint is given by the following equation:

$$\begin{aligned} P^C_{q,t,g}(1 + \tau^C)C_{q,t,g} + B_{q,t+1,g+1} - (B_{q,t,g} + \mathcal{U}_{q,t,g}) = \\ (1 - \tau^W_t - CTR_t)\psi_{q,g,t} + i_t(1 - \tau^K)(B_{q,t,g} + \mathcal{U}_{q,t,g}) + \mathcal{P}_{q,t,g}, \end{aligned} \tag{7}$$

where P^C is the price of the households' consumption basket, C is the level of consumption, B are the households' savings, $\mathcal{P}$ is the received PAYG pension payment (only nonzero for households above the statutory retirement age), CTR is the contribution rate to the PAYG pension system, i is the interest rate and τ^C, τ^W and τ^K are consumption, wage and capital tax rates.

Similar to, for example, Magnani and Mercenier (2009), each representative consumer chooses to allocate their working time among the sectors, maximizing their total income under a CET constraint:

$$LS_{q,a,t} = \left(\sum_s \alpha^S_{a,s,q} (LSS_{s,q,a.t})^{\frac{1-\sigma^L}{\sigma^L}} \right)^{\frac{\sigma^L}{1-\sigma^L}}. \tag{8}$$

2.3 Government and other Markets

A relatively small pay as you go pension system represents the Swiss Old-age and survivor's insurance (OASI). The size of pension payments is based on the mean of the households' lifetime income, multiplied with a fixed replacement rate $\mathcal{R}$. Contributions to the pension are deducted from workers' labor income, with a contribution rate CTR chosen in every period such that the pension payments can be financed fully.

The economy is assumed to be linked to the world market via imports and exports. However, the rest of the world is not modeled explicitly. The aggregate trade balance is assumed to remain constant, world market prices adjust to reflect this. The government raises taxes on income, consumption and capital, from which it finances its expenditures. Expenditures are allocated to the sectors by a CES function and are assumed to grow at the same rate as the population. The government is allowed to run a deficit, however in the long run the budget is assumed to be balanced.

A complete list of model equations is presented in Appendix A.

3 Data and Calibration

As recommended by Buchmann (2020), the four skill levels are defined by competence levels, which in turn are based on occupations. For a full description of the competence levels and their advantages over more traditional definitions of skill levels, see Buchmann (2020). The age groups are defined as follows: young workers are ages 20-34, middle-aged workers are ages 35-49, old workers are ages 50-64 and post-retirement-age workers are ages 65-79. Households over the age of 79 are assumed to be retired completely, reflecting the fact that observed participation rates are almost zero at this age. The aggregation of sectors is based on the General Classification of Economic Activities (NOGA) of the Swiss Federal Statistical Office (SFSO). Table 9 lists the aggregation of NOGA industry sections into the model sectors.

Initially, the economy is assumed to be in a steady state in 2010. After 2010, the demographic shock is implemented. I report model results from 2020 onwards, giving the model 10 periods to react to the initial shock and move to its transition path. All demographics starting in 2020 are based on the official projections of the Federal Statistical Office (2020). The size of the 20-year-old cohort is taken directly from the projections. Combined with the projected mortality rates and migration movements, the model replicates the complete projected demographics until 2070. After 2070, fertility, mortality, and migration are assumed to remain constant at the 2070 level, leading to a stable population size in the long run. A new steady state is enforced in the year 2200. Migration is not assumed to be equally distributed among skill levels. Instead the current skill levels of migrants are assumed to remain unchanged during the demographic transition. This distribution is based on the Swiss Labor Force Survey and displayed in Table 1. As migrants are more likely to be very high or low skilled than Swiss, this leads to an increase in the relative abundance of very high and low skilled workers.

Participation rates are represented by the leisure parameter ℓ. Steady state participation rates are chosen such that the model replicates the full-time-equivalent participation rates 2015-2017 as calculated by the SFSO as closely as possible in the period 2015. The utility weight on leisure α can then be calibrated based on the steady-state values for ℓ. Figure 2 compares the full-time-equivalent participation rates as observed by the SFSO to the calibrated participation rates $1 - \ell$ in 2015. The calibration comes fairly close to real values, with the exception of workers above the statutory retirement age. Here, the model predicts higher participation rates than observed in the data. However, those participation rates are still very low.

The efficiency parameter ε is estimated with data from the 2015 Swiss Labor Force Survey using a simple Mincer (1958) style wage equation, regressing log wages on age, age-squared and sex in each qualification level.

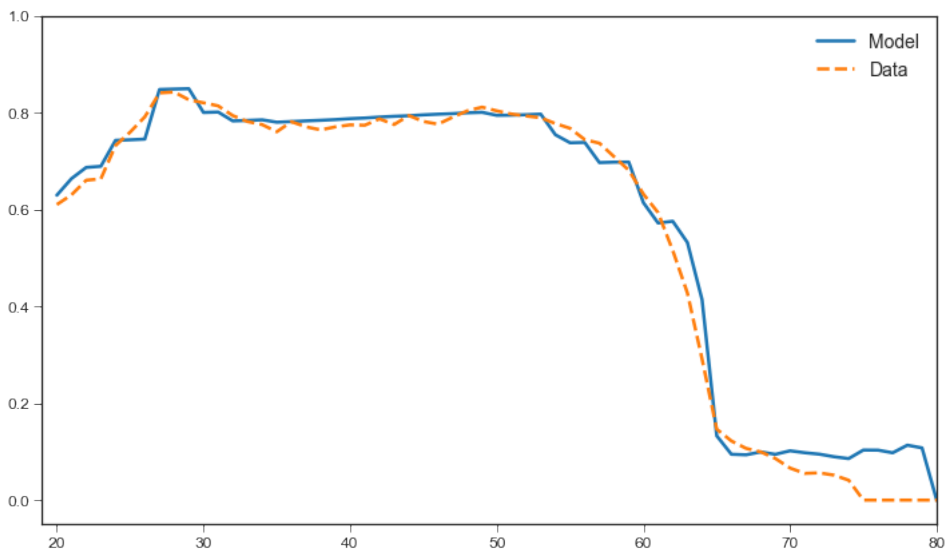
The industry structure, i.e. intermediate inputs, export and import shares, capital

Table 1: Distribution of qualification levels

	Very High Skilled	High Skilled	Medium Skilled	Low Skilled
Swiss	33%	20%	43%	4%
Migrants	49%	13%	33%	5%

Source: Swiss Labor Force Survey 2015

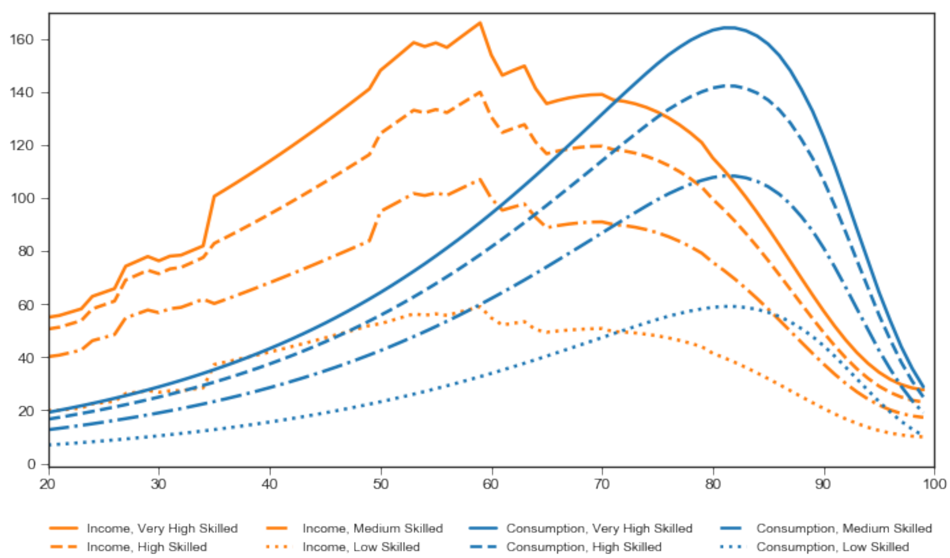
Figure 2: Calibrated versus observed participation rates



Note: Simulated value of $(1-\ell)$ in 2015 versus full-time-equivalent participation rates 2015-2017 as calculated by the SFSO, based on the Swiss Labor Force Survey. X-axis corresponds to age in years.

shares and final use of the produced goods is calibrated with the Swiss Input-Output Table 2014 (SFSO, 2018). The shares of the different types of labor (i.e. skill and age groups) in each industry are calibrated using the Swiss Labor Force Survey 2015. ξ is then calibrated such that labor supply in efficiency-units matches labor demand for each skill and age group. Figure 3 displays the simulated steady-state income and consumption profiles.

Figure 3: Consumption and Income Profiles



Note: Simulated income and consumption profiles. Income includes labor income ψ, capital income rB and transfer income $\mathcal{P}$ and $\mathcal{U}$. X-axis corresponds to age in years. Y-axis corresponds to Swiss Franks in thousand.

The intertemporal elasticity of substitution is assumed to be 0.9. This value is higher than what is usually assumed in the literature, however, this elasticity in combination with the given mortalities and relatively high number of old generations best replicates the observed life-cycle consumption pattern. A lower value would vastly overestimate the consumption of the older generations. In Section 5 I show how the results of the model change if a more common elasticity is chosen. Martinez et al. (2018) find very low Frisch elasticities for Switzerland. To account for this observation, the intratemporal elasticity of substitution is assumed to be equal to the intertemporal elasticity of substitution. The annual depreciation rate δ is assumed to be 0.05. Based on the inter- and intratemporal elasticities and δ, the rate of time preference γ is calibrated to be 0.031 and the steady state interest rate is calibrated as 0.08.

The labor market elasticities σ^Q and σ^A are set to 3 and 3.6, respectively. This assumption is based on Buchmann (2020) where, using the same data, I estimate an aggregate elasticity of substitution between skill levels of 2.8, with sectoral elasticities generally being slightly higher, and an elasticity of substitution between the appropriate age groups of 3.624. As I do not find robust differences between sectors, I assume the same elasticities across all sectors. The elasticity of transformation between sectoral employment σ^L is assumed to be -1.5. I assume a fairly low transformability since the number of sectors is relatively low and therefore sectors should not be very similar. Magnani and Mercenier (2009) generate elasticities in the same range for the choice of occupation. The sensitivity of model outcomes to this parameter choice is evaluated in Section 5.

Table 2: Exogenous Parameter Values

Symbol	Definition	Value
ρ	Intertemporal elasticity of substitution	0.9
θ	Intratemporal elasticity of substitution	0.9
δ	Depreciation rate	0.05
$\mathcal{R}$	Replacement rate	0.31
τ^C	Consumption tax rate	0.042
τ^W	Income tax rate	0.384
τ^K	Capital tax rate	0.018
σ^Q	Elasticity of substitution between skill levels	3
σ^A	Elasticity of substitution between age groups	3.6
σ^L	Elasticity of transformation between sectoral employment	-1.5
σ^I	Elasticity of substitution between origin of investment	3
σ^G	Elasticity of substitution between sectoral government spending	2.5
σ^M	Armington Elasticity between origin of consumption	1.5
σ^X	Armington Elasticity between destination of production	-1.5

The pension system is based on a simplified version of the first pillar of the Swiss pension system OASI (Old Age and Survivor Insurance). This is a state run, pay-as-you-go pension scheme, partially also financed by various taxes (e.g. VAT, tobacco, gambling). For the purposes of this model, I neglect the external financing of the pension and only model the wage contribution. I choose the pensions' replacement rate $\mathcal{R}$ such that the resulting steady-state contribution rate CTR matches the true wage contribution rate of 8.7%. The resulting replacement rate is 0.31. The second (mandatory pension fund) and third (voluntary tax-deductible pension fund) pillar of the pension system are not modeled explicitly.

4 Results

4.1 Demographic Transition

First, I present results for the baseline model, i.e. the effects of the demographic shock alone. The effect of the demographic transition on different macroeconomic variables is summarized in Table 3. Where applicable, results represent percentage changes compared to 2020 measured per working age population. GDP per capita first stagnates until around 2040 and then starts falling as the demographic pressure increases. The capital stock keeps growing for a longer time as a consequence of the labor shortage and the implied shift from labor to capital in the production of goods. Meanwhile, the share of consumption is increasing while the share of investments is decreasing. The relative abundance of capital also leads to a consistently falling interest rate. The tax burden decreases initially, however during the second half of the transition the tax burden starts increasing again, reflecting the decrease of per capita income. The contribution rate to the PAYG pension system has to increase drastically in order to finance the larger amount of retirees.

Table 3: Macroeconomic Results of Baseline Model

	2020	2030	2040	2050	2060	2070
GDP[a]	1.000	1.012	1.001	0.991	0.978	0.965
Capital Stock[a]	1.000	1.045	1.059	1.058	1.048	1.030
Share of Investment[b]	0.319	0.310	0.294	0.283	0.275	0.271
Share of Consumption[b]	0.551	0.561	0.576	0.585	0.591	0.595
Interest Rate	0.072	0.069	0.067	0.066	0.066	0.067
Income Tax rate	0.329	0.321	0.325	0.330	0.335	0.341
Contribution Rate	0.086	0.100	0.115	0.126	0.140	0.149

[a] Measured per capita (aged 20 and above) and indexed at 1 in 2020
[b] Share relative to total GDP

Table 4 shows the share of each sectors' output on aggregate output at different points in time. Most affected are the sector aggregates construction and health. Construction's share of output decreases by 12% from 6.81% to 6%, whereas health's share of output increases from 5.96% to 6.27%, or 5%. Other losers include manufacturing, IT and agriculture while other sectors who are relatively better off after the demographic transition include finance, trade & transport and other services.

Figure 4 shows how the participation rates $(1 - \ell)$ of differently aged households change during the demographic transition. Participation rates of younger and middle-aged workers only marginally change during the transition, despite largely increasing wage levels. However, older households noticeably react to the changing

Table 4: Sectoral Impact of Population Aging

	2020	2030	2040	2050	2060	2070
Manufacturing	29.82	29.82	29.67	29.58	29.52	29.46
Finance	20.82	21.11	21.27	21.33	21.36	21.33
Construction	6.81	6.58	6.32	6.16	6.06	6.00
Trade and Transport	18.41	18.48	18.57	18.64	18.70	18.72
IT	4.39	4.36	4.31	4.26	4.23	4.21
Other Services	12.76	12.65	12.75	12.84	12.92	13.00
Health	5.96	5.98	6.10	6.17	6.21	6.27
Agriculture	1.03	1.02	1.01	1.01	1.01	1.00

Shares of sectoral output relative to aggregate output, in %.

circumstances. 60 year-olds initially increase their labor supply, as older workers (aged 50-64) become relatively more scarce due to the retirement of the baby-boomer generation. After 2030, when the largest part of the baby-boomers is retired, labor supply of older workers remains constant until 2045 when the second wave of the demographic transition hits and old labor becomes even more scarce, which leads to another increase in participation rates. Workers above the retirement age, here represented by 65 year-olds, slightly increase their labor supply initially but, due to the relative abundance of workers in this age group and thereby falling wages, start decreasing it once the baby-boomers are retired. After the baby-boomers leave this age bracket, labor supply is increased again before it falls once again as the second wave of the transition completes. In all age brackets, the differences between qualification levels are caused by qualification-specific immigration which changes the relative scarcity of qualified labor and therefore relative wages and incentives to change labor supply.

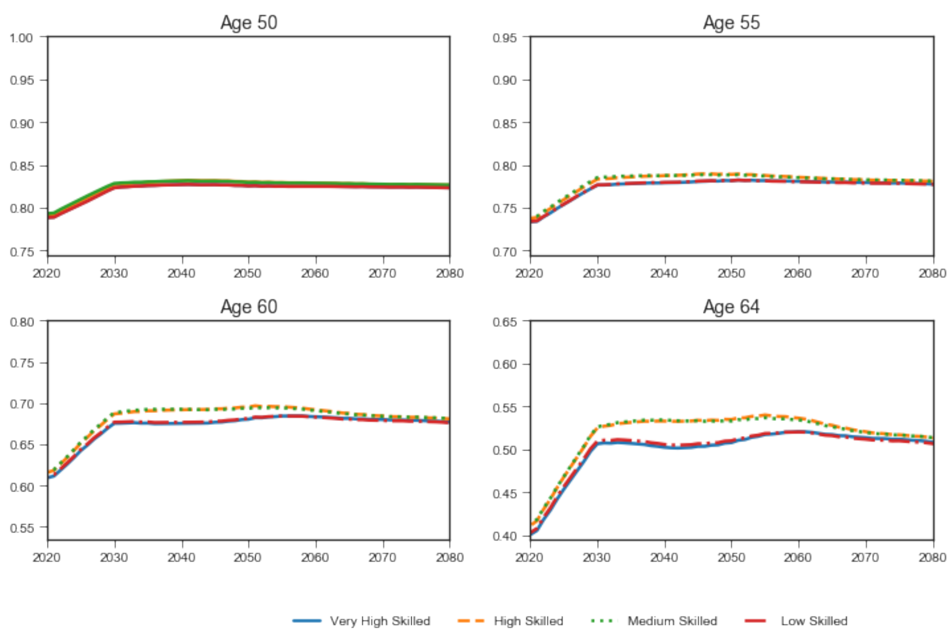
As a measure for labor shortages, Table 10 in the Appendix displays the development of the disaggregated wage rates relative to 2020. As a first observation it is clear that wages for the middle two qualification levels increase more than the wages of the very high- and low-skilled workers. Again, this is due to the composition of immigration which increases the relative scarcity of the medium qualification levels. It is also notable that wages in the health sector increase rapidly and strongly. This indicates a high chance of labor shortages in this sector in the coming decade. While the wages in the health sector show the sharpest increase, wages for young and middle aged workers increase in all sectors to varying degrees. Wages for old workers only show strong increases in the medium qualification levels, high- and low-skilled old workers experience much more moderate wage increases. Post-retirement-age workers only experience notable wage increases in the health sector, in all other sector wages stagnate or even fall. This is a sign of the relative abundance of post-retirement workers during the demographic transition.

Figure 4: Participation rates of differently aged households during the demographic transition

4.2 Increasing participation rates of old workers

I now turn to the first policy reform. This reform represents a successful increase in the participation rate of workers between the age of 50 and 64. This paper remains agnostic about how this increase was achieved. Potential reforms could include incentives for a delayed early retirement or incentives for firms to hire older workers. Within the model, the reform is implemented by incrementally decreasing the preference parameter for leisure α by 2% every year between 2021 and 2030. This corresponds to a final increase in the participation rates of around 7%, however the exact increase depends on the initial participation rates, i.e. generations who participated less initially are affected more strongly. Figure 5 shows how participation rates are affected for a range of age groups. The shocks result in participation rate increases between 4% and over 10%, depending on the exact age.

Figure 5: Participation rates of affected households before and after old worker participation rate increase



The macroeconomic effects of this shock are displayed in Table 5. The positive participation rate shock leads to some economic growth in the first decade which manages to offset the negative effects of demographic change at least until 2040. At this point the demographic effects start to dominate, leading to a decreasing GDP per capita.

Table 5: Macroeconomic Results of Old Workers Participation Rate increase

	2020	2030	2040	2050	2060	2070
GDP[a]	1.000	1.020	1.012	1.005	0.993	0.981
Capital Stock[a]	1.000	1.047	1.067	1.069	1.062	1.045
Share of Investment[b]	0.318	0.312	0.295	0.284	0.276	0.271
Share of Consumption[b]	0.552	0.561	0.576	0.586	0.593	0.596
Interest Rate	0.072	0.069	0.068	0.067	0.066	0.067
Income Tax rate	0.329	0.318	0.321	0.325	0.329	0.334
Contribution Rate	0.086	0.099	0.115	0.126	0.139	0.148

[a] Measured per capita (aged 20 and above) and indexed at 1 in 2020
[b] Share relative to total GDP

Table 11 in the Appendix displays the sectoral impact of population aging with an increase of the participation rates of old workers. The results do not differ much from the results without the shock, differences are marginal at best.

Table 12 displays the development of disaggregated wages with a participation rate increase of old workers. Wages of old workers are around 1.5%-3% lower than in the baseline scenario without a participation rate increase. This implies a reduction of shortages in old labor in particular. However, despite the increase in labor supply, wages still increase significantly, indicating that this participation rate increase does not compensate the reduction in labor supply caused by the retirement of baby-boomers.

4.3 Increasing the Retirement Age

The increase of the retirement age is implemented incrementally over two years and contains two components. First, in the year 2021 pensions are not paid out to 65 year-olds anymore, thus increasing the statutory retirement age to 66. At the same time, the preference parameter for leisure α of 65 year-olds is decreased by 30%. This is necessary because the model neglects behavioral aspects in its definition of the utility function and therefore the difference in income alone does not induce a realistic increase in participation rates. In the year 2022, the statutory retirement age is further increased to 67 and 66-year olds' α is also reduced by 30%. After both shocks are implemented, participation rates of 65 and 66 year-olds are on a similar level as participation rates of 64 year-olds before the reform.[2] The resulting

[2]This target can be considered as a likely upper bound for the true change in participation rates. Assuming a lower participation rate might be more realistic, however

effects on participation rates is displayed in the Appendix, Figure 13.

Table 6: Macroeconomic Results of retirement age increase

	2020	2030	2040	2050	2060	2070
GDP[a]	1.000	1.019	1.011	1.005	0.995	0.986
Capital Stock[a]	1.000	1.051	1.071	1.076	1.071	1.058
Share of Investment[b]	0.320	0.313	0.297	0.287	0.280	0.275
Share of Consumption[b]	0.550	0.559	0.574	0.583	0.590	0.593
Interest Rate	0.072	0.069	0.067	0.066	0.066	0.066
Income Tax rate	0.329	0.318	0.321	0.324	0.328	0.332
Contribution Rate	0.086	0.083	0.099	0.109	0.120	0.129

[a] Measured per capita (aged 20 and above) and indexed at 1 in 2020
[b] Share relative to total GDP

Table 6 shows the macroeconomic outcomes of the retirement age increase. The results are very similar to the participation rate increase discussed in the previous section, in particular with respect to GDP per capita. The major difference is the development of the contribution rate. Due to the increase of the retirement age, the total amount of pensions paid out decreases which leads to a lower contribution rate. It should also be noted that the size of pension payments is slightly lower as well because the size of the pension is based on average lifetime labor income and labor income at the age of 65 and 66 is below average. Additional results, such as the development of wages and sectoral results are displayed in Appendix C. Most notable here is that wages for most households are actually higher than in the baseline scenario. This is caused by the higher net income due to lower contribution rates and thereby higher consumption demand which also leads to a higher demand for labor. Only wages of workers above the age of 64 are reduced significantly, however this group only makes up a small share of the labor force, even with the retirement age increase.

4.4 Increasing Participation Rates of Women

Since the model does not discriminate between male and female households, a participation rate increase of women cannot be implemented directly. Instead, the shock is implemented by multiplying the shock applied in Section 4.2 with the full-time-equivalent share of women in each age group. This results in a shock that is equivalent to the old age participation increase shock but applied to women instead. The shock is applied to households between the ages of 28 and 64. The

without assumptions on early retirement schemes and the detailed formulation of the law it is impossible to gauge the true extent of participation rate increases.

lower bound is chosen because this is the point where participation rates between men and women start to diverge. Participation rates of younger men and women are almost identical. Appendix Figure 14 shows the resulting participation rate responses for some representative age groups.

Table 7: Macroeconomic Results of women's participation rate increase

	2020	2030	2040	2050	2060	2070
GDP[a]	1.000	1.019	1.011	1.003	0.991	0.980
Capital Stock[a]	1.000	1.047	1.066	1.069	1.062	1.045
Share of Investment[b]	0.318	0.312	0.295	0.284	0.276	0.272
Share of Consumption[b]	0.552	0.560	0.576	0.586	0.592	0.596
Interest Rate	0.072	0.069	0.068	0.067	0.066	0.067
Income Tax rate	0.329	0.319	0.322	0.326	0.330	0.335
Contribution Rate	0.086	0.099	0.115	0.126	0.139	0.148

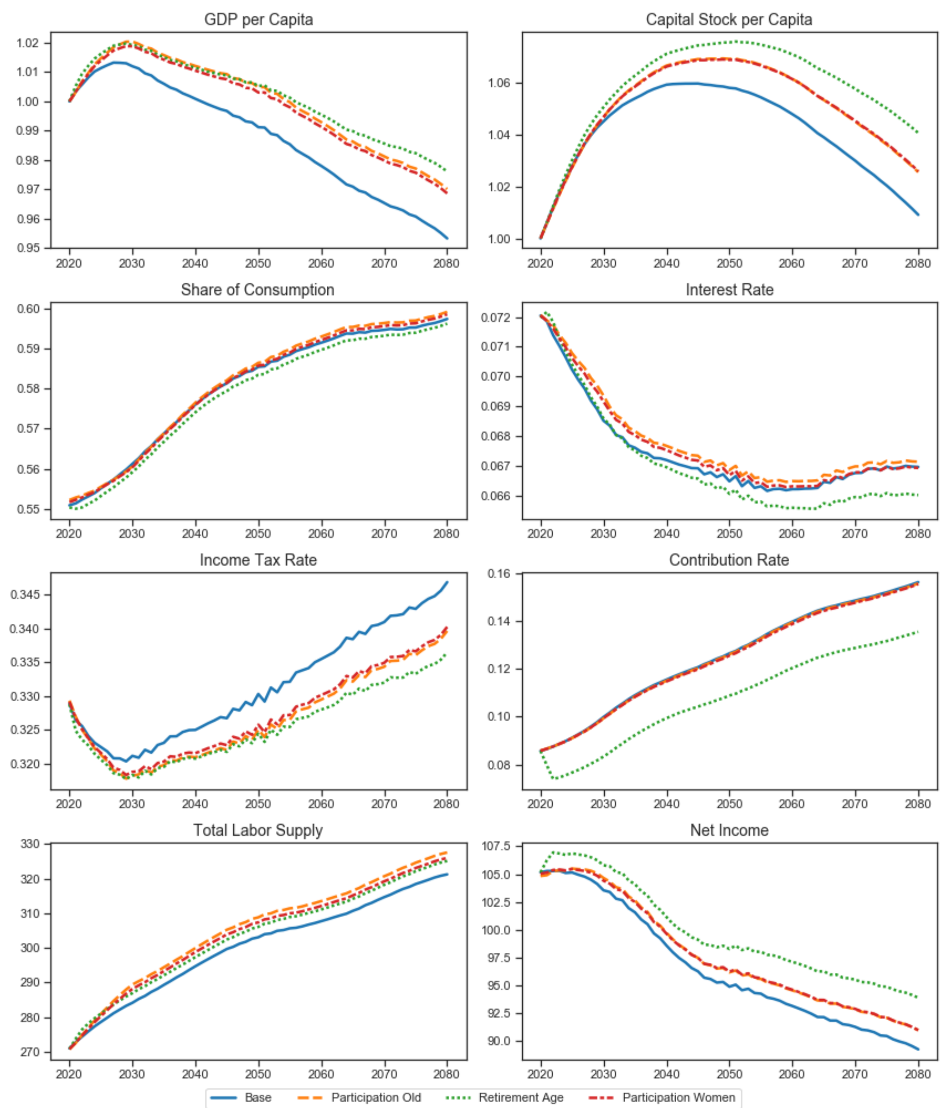
[a] Measured per capita (aged 20 and above) and indexed at 1 in 2020
[b] Share relative to total GDP

The macroeconomic effects of this reform are displayed in Table 7. The effects are almost identical to the increase in old workers' participation rates but tend to be marginally lower. Additional results, such as the development of wages and sectoral results are displayed in Appendix C.

4.5 Comparison of the Scenarios

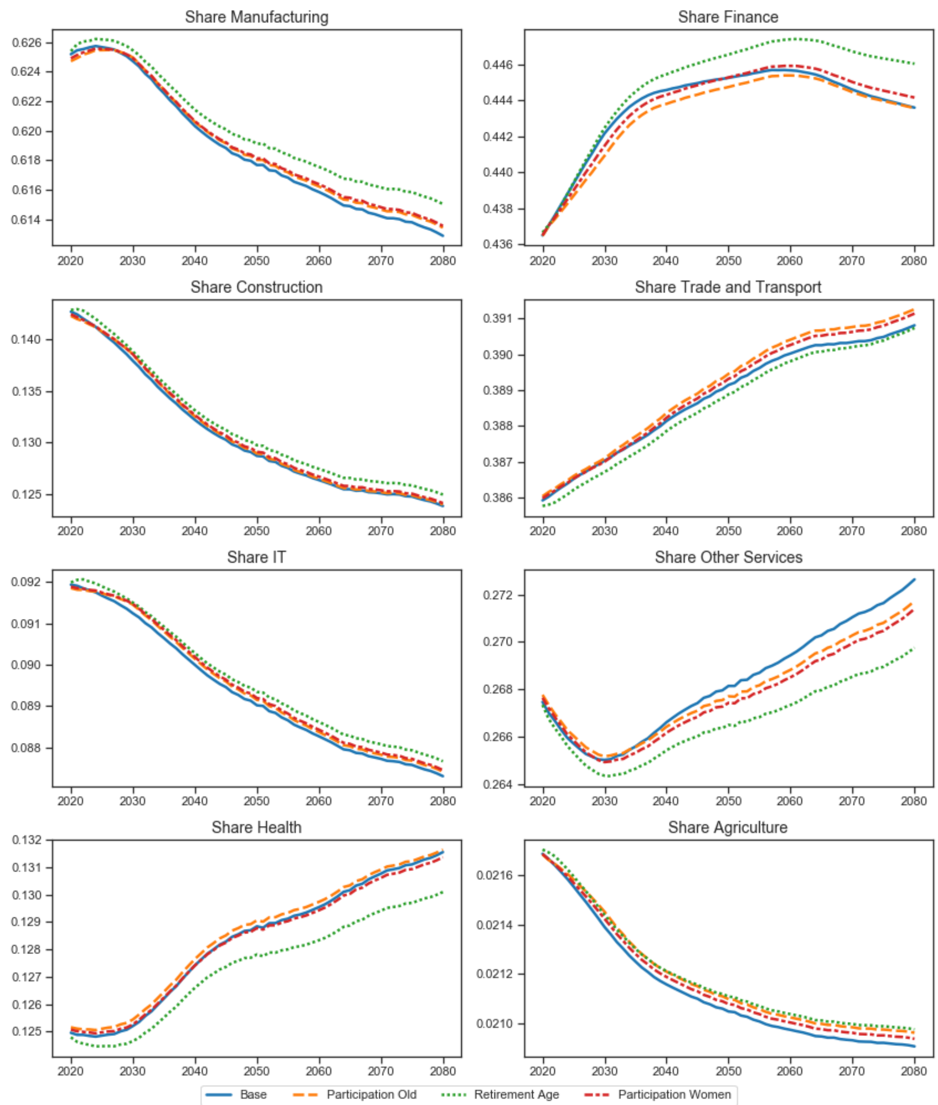
Figure 6 graphically compares the macroeconomic outcomes of the different scenarios presented above. The first panel compares the GDP per capita, which is very similar across all scenarios. In the very long term the retirement age increase performs slightly better but even then the differences are small. The capital stock increases more with the retirement age increase than with the participation rate increases while the shares of consumption and investment on GDP do not differ significantly between the scenarios. The retirement age increase at first does not affect the interest rate, however in the medium to longer term the interest rate converges to the level achieved with the participation rate increases. Income tax rates drop with all the reforms compared to the scenario without reform. In the short and medium term the drops are the same across all reforms, in the longer term the retirement age increase has the largest drop. Naturally, contribution rates to the pension system are much lower in the retirement age increase scenario due to the lower amount of pensions being paid out. As a direct consequence, the retirement age reform leads to the largest positive effect on net incomes. However, all reforms affect net income positively, despite partially decreasing wages. This indicates that not only producers, but also consumers stand to benefit from all suggested reforms.

Figure 6: Development of macroeconomic variables in different scenarios



As can be observed in Figure 7, relatively speaking, the manufacturing and finance sectors benefit more from a retirement age increase whereas other services and the health sector benefit the least from a retirement age increase. Participation rate increases do not affect sectors very differently.

Figure 7: Development of sectoral shares in different scenarios



In a general equilibrium framework wages act as an equilibrating force for the labor market. However, in reality one cannot expect extreme wage changes due to the institutional framework, stickiness of wages and other reasons. Instead, the scarcity of labor manifests itself in labor shortages. The size of the wage increases predicted by the model serve as an indicator for the extent of expected labor shortages. Figure 8 compares aggregated wages in each sector across the different scenarios. As has already been clear in the disaggregated view presented in the preceding sections, the model predicts wages to rise significantly in all sectors during the demographic transition. Despite the increase in labor supply due to 65 and 66 year olds working more, the retirement age increase scenario predicts wages to increase even more than the baseline scenario. This is due to the feedback effect of an increase in output also increasing the demand for labor. Thus, in this scenario the demand effect dominates the supply effect and the reform fails to reduce labor shortages. Both participation rate increase scenarios reduce aggregated wages in all sectors and almost all time periods, however, meaning that here the supply effect dominates. The participation rate increase for old workers tends to be slightly more effective than the corresponding participation rate increase for women.

5 Sensitivity Analysis

5.1 Sensitivity with respect to the intertemporal elasticity of substitution

With a value of 0.9, the elasticity of substitution chosen for the baseline scenario in this paper is higher than in most other studies. For example, Auerbach and Kotlikoff (1987), Altig et al. (2001) and Kotlikoff et al. (2007) use 0.25, Keuschnigg et al. (2011) use 0.35. Havranek et al. (2015) survey a large amount of studies estimating this elasticity and find a mean of 0.5, however this result varies a lot across country, data and methodology used. For Switzerland the mean is -0.434 based on 31 estimates, with observations ranging from -3.44 to 1.37. Most of these results are not statistically significant. However, Havranek et al. (2015) also find that in countries with higher GDP per capita and higher stock market participation intertemporal elasticities of substitution tend to be higher.

The intertemporal elasticity of substitution is a very relevant parameter in a life-cycle model because it directly affects the Euler equation and thereby the distribution of consumption across the life-cycle. In the context of population aging this is particularly important because this determines how much old generations consume. Figure 9 shows, how steady-state consumption across the life-cycle of very high-skilled consumers is affected if lower elasticities of substitution are chosen. [3]

It is clear that a lower elasticity leads to a shift in consumption from ages 50-80 to

[3] For ease of comparison, the version of the model shown in this chapter simplifies the assumptions about initial participation rates somewhat, as the algorithm fails to find a solution for some of the parameter values that are compared if initial participation rates vary too much over the life-cycle. Therefore the baseline solution slightly differs from the main model.

Figure 8: Development of sectoral wages in different scenarios

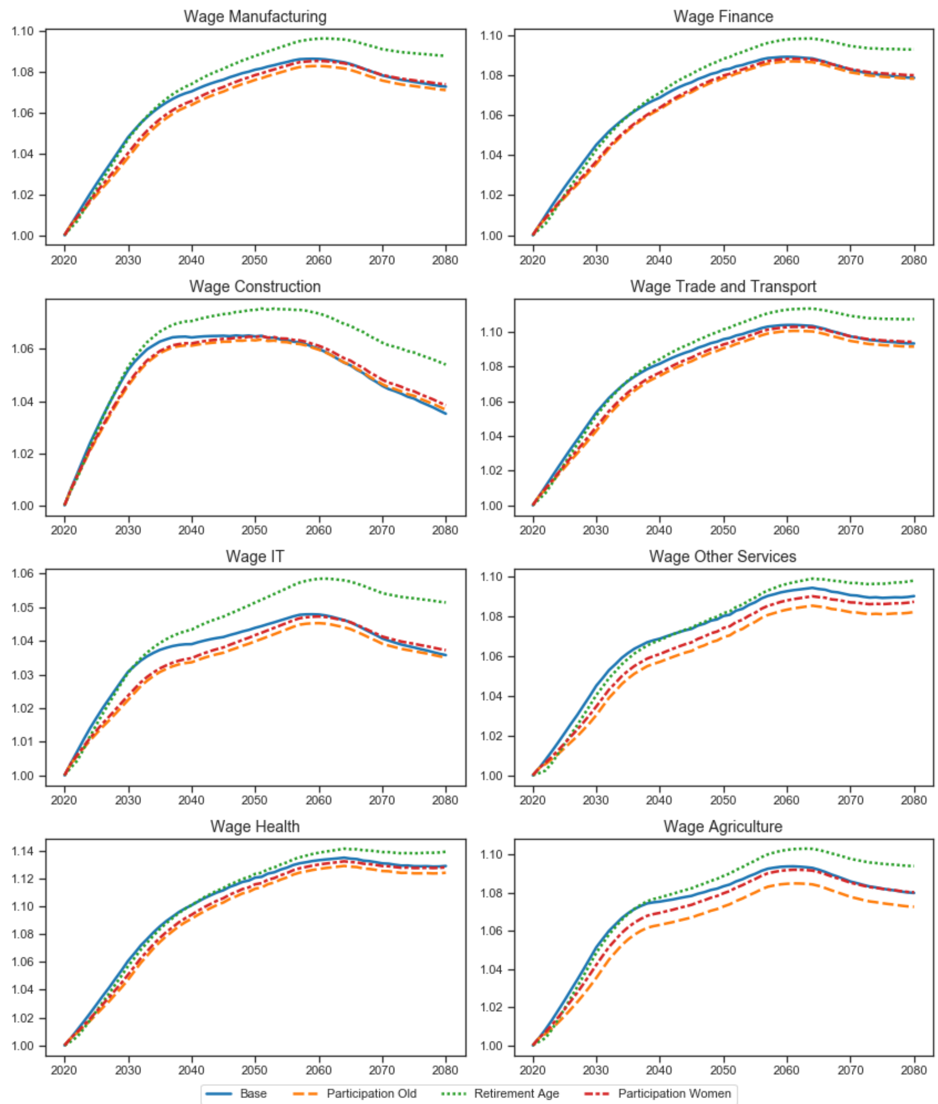
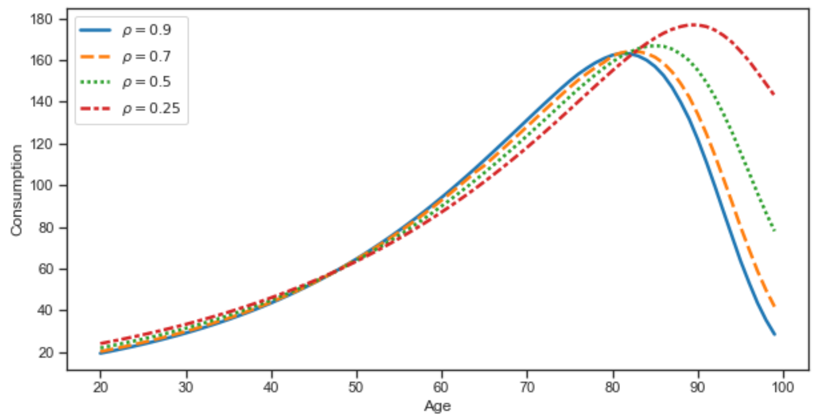


Figure 9: Life-cycle consumption pattern with different intertemporal elasticities of substitution



age 80 and higher as well as to a lower extent 50 and lower. This stronger tendency towards consumption smoothing also leads to a lower discount factor. How this affects the model outcomes can be seen more clearly in Figure 10, where various macroeconomic variables are compared along the demographic transition, as well as Figure 11, where some sector-specific results are evaluated for selected industries[4]. In terms of GDP and capital stock per capita, the intertemporal eslasticity of substitution matters a lot. Based on Figure 9 this is to be expected: if older generations consume a lot and the population becomes older on average, then total demand should be higher. With an elasticity of 0.25, GDP per capita increases by 15% during the demographic transition, even without assuming any technological progress, whereas with an elasticity of 0.5 it remains roughly constant. Due to the higher consumption of older generations, the total share of consumption is decreasing with the IES, reflecting the need for higher savings. As a direct consequence, interest rates decrease faster with a higher IES. Due to the higher GDP, tax and contribution rates don't increase as much with a higher IES. The sectoral results, as displayed in Figure 11 also differ significantly depending on the choice of IES. Wage rates in both sectors increase much more if a lower IES is chosen, reflecting the better economic conditions due to the higher demand and therefore a higher need for labor, increasing the scarcity on the labor market. How the sectors are affected by the demographic change also changes. In particular, the share of the health sector does not increase during the transition with very low elasticities. The

[4]For the sake of brevity I only report results for the health and construction sectors which are the two sectors that are most strongly affected by the demographic change.

Figure 10: Macroeconomic changes with different intertemporal elasticities of substitution

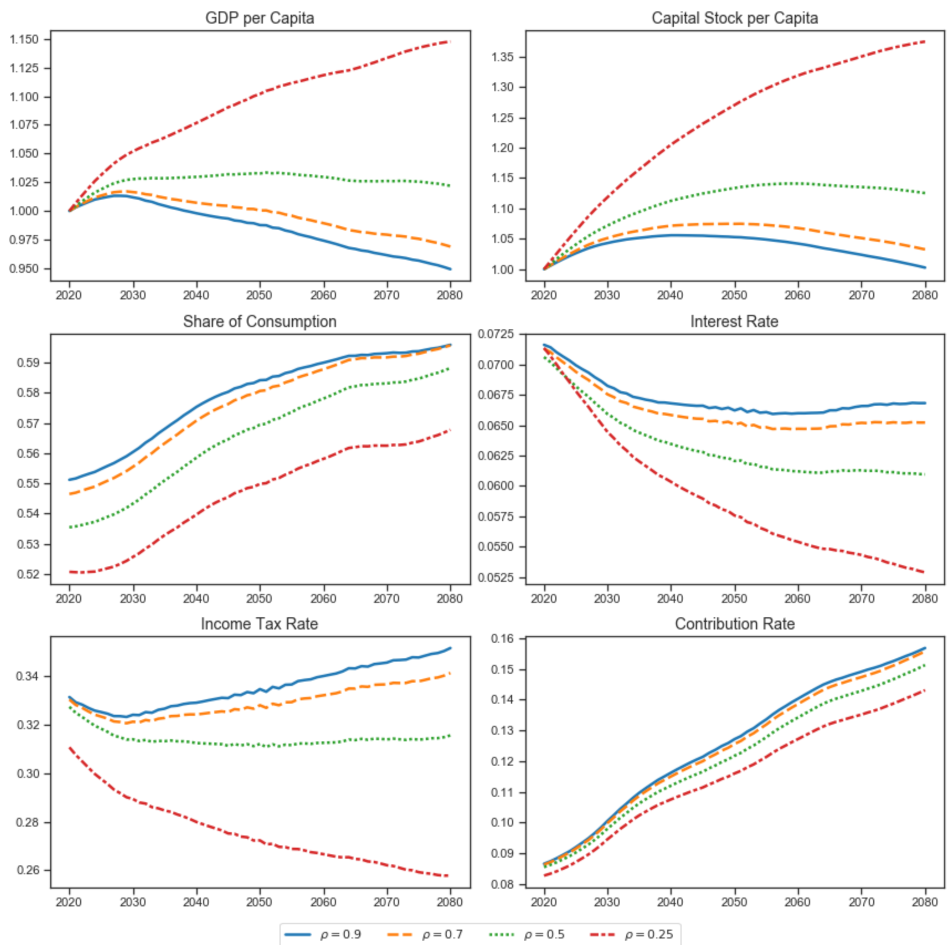
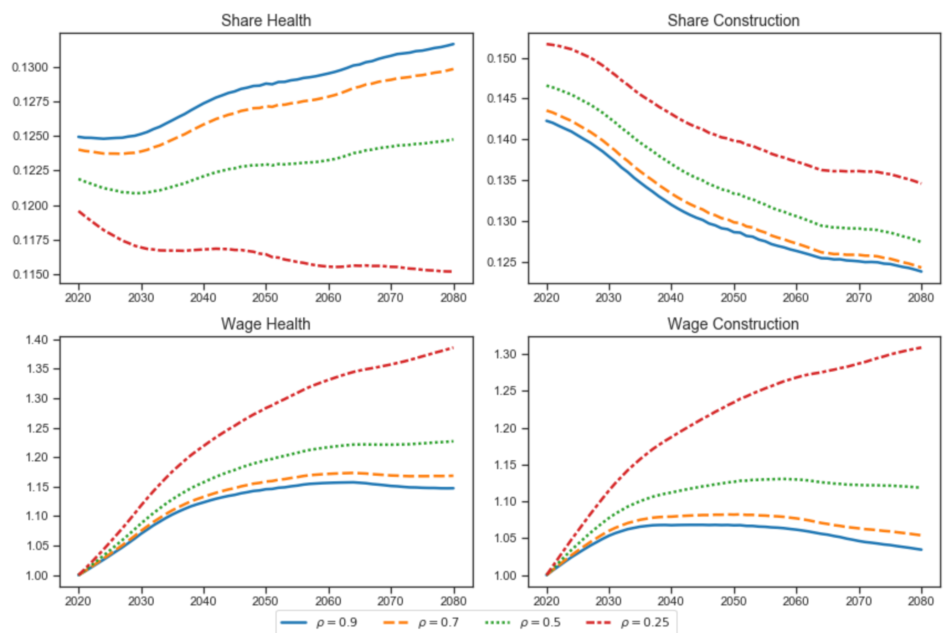


Figure 11: Sectoral changes with different intertemporal elasticities of substitution



share of the construction sector is generally higher with higher IES, mostly due to the higher demand for investments.

Given these large differences, the choice of IES matters a lot. I argue, that replicating the true life-cycle pattern of consumption as closely as possible is the most important factor when choosing an IES. The Swiss data show a decline in consumption spending after age 65, i.e. the statutory retirement age. A perfect replication of this pattern with the model used in this paper is not possible. Modeling of child-rearing, as in, for example, Kotlikoff et al. (2007), would be necessary to reflect this behavior. The IES of 0.9 used in the main specification of the model is the closest approximation of true consumption patterns given the model at hand and is therefore chosen as the main specification.

5.2 Sensitivity with respect to the elasticity of transformation between sector affiliation

The way in which sectoral labor supply is modeled in this paper necessitates a somewhat arbitrary choice of the elasticity of transformation. As to my knowledge, at the time of writing this paper no estimates of this elasticity are available, and even if there are, the estimates would depend strongly on the aggregation of sectors. In any case, choosing a sector to work in is an artificial construct which helps simplify the model. In the real world, a choice of occupation is much more realistic. Magnani and Mercenier (2009) simulate a dataset and calculate the resulting elasticity of transformation between occupational choice. This results in elasticities in the range of -1.375 to -1.7. In the baseline specification of this model I use a value of -1.5. In this section I show how the results are affected if more extreme values of -1.1 and -2 were chosen instead.

Figure 15 shows that macroeconomic variables are barely affected by the choice of this parameter. However on the sectoral level, differences are expected. Indeed, Figure 16 reveals that a higher (in absolute terms) elasticity of transformation leads to reduced changes in the relative importance of sectors, whereas a lower elasticity exacerbates the changes. This is expected as a higher elasticity means that workers move across sectors more easily. At the same time a higher (lower) elasticity of transformation leads to higher (lower) wage increases in the health and wage decreases in the construction sector. Overall however, the differences are fairly small and don't affect the interpretation of model outcomes strongly.

5.3 Alternative Demographic Assumptions

The Swiss Statistical Office Federal Statistical Office (2020) introduces several alternative scenarios concerning the forecast of population developments in Switzerland.

A number of these scenarios affect the available labor supply by changing assumptions concerning fertility or migration.[5] In this section, I evaluate how different assumptions affect the model outcomes and compare these changes to the effects of participation rate or retirement age reforms. Table 8 describes the differences between assumptions of the official scenarios presented in Federal Statistical Office (2020).

Table 8: Alternative demographic assumptions

Scenario	Children/woman	Age at birth	Immigration	Emigration
Reference	1.62	33.4	165,000	130,000
High Fertility	1.82	32.9	165,000	130,000
Low Fertility	1.41	33.9	165,000	130,000
High Migration	1.62	33.4	190,000	140,000
Low Migration	1.62	33.4	140,000	120,000

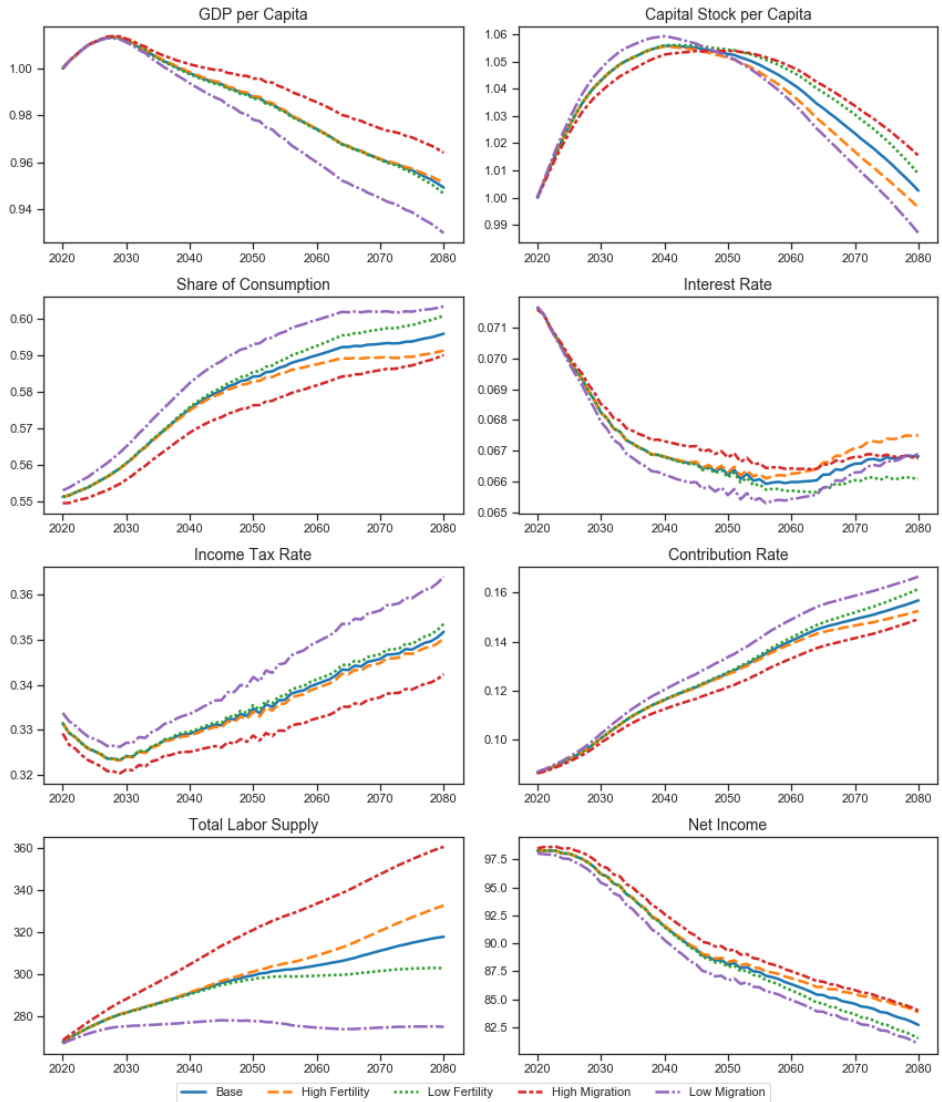
Note: Assumed values in the year 2050. Source: Federal Statistical Office (2020)

In the past, fertility has been steadily decreasing in Switzerland. The mean number of children per woman has decreased from 2.07 in 1940 to 1.52 in 2010 and has increased back to 1.54 since then, largely due to an increase in immigration. Mothers' mean age at birth is fairly high and increasing, from 31.2 in 2009 to 32.2 in 2019. Due to an improvement in childcare opportunities in recent years, Federal Statistical Office (2020) expects a slight increase in birth rates in the near future. In the reference scenario, an increase from 1.52 children per woman in 2020 to 1.62 in 2050 is assumed. The mean age at birth is assumed to increase to 33.4 in 2050 due to a higher share of tertiary educated women as well as improvements in reproductive medicine. In the high fertility scenario the statistical office assumes that a more dynamic family policy will lead to a moderate increase in the birth rate up to 1.82 in 2050. Due to more optimistic assumptions concerning the fertility of immigrated women the mean age at birth is assumed to only increase slightly to 32.9 in 2050. The low fertility scenario assumes a continuation of socioeconomic trends, i.e. an increase in individualism and valuation of leisure and freedom, where many couples do not marry or cannot afford children in combination with their desired lifestyle. Hence, the birth rate is assumed to further decrease to 1.41 children per woman by 2050. Mean age at birth is assumed to further increase to 33.9.

Due to its relatively small population size and very attractive working conditions, migrants play a very important role for the Swiss labor market. Current migration trends are strongly linked to Switzerland joining the Schengen area in 2008, allowing for free movement of labor from and to other Schengen countries. This has led net

[5] Assumptions concerning mortality only affect the labor supply of a developed country marginally, as mortality rates of the working age population are extremely low with all reasonable assumptions. Therefore, these assumptions are not discussed here.

Figure 12: Impact of demographic assumptions on macroeconomic results



migration to increase from a low of 36,000 in 2005 to a high of 98,000 in 2008. Since then however, net migration decreased again to 55,000 in 2019. This decrease was at first caused by a drop in immigration after the initial influx following the opening of the borders, however more recently an increase in emigrations has been observed as the main reason for the decrease in net migration. Due to the higher demand for labor of Swiss firms caused by the demographic transition, the reference scenario in Federal Statistical Office (2020) assumes the number of immigrants to increase from 176'000 in 2020 to 185,000 in 2030 and then decrease again to 165'000 in 2050. Due to immigrants returning to their home countries, emigrations are assumed to slightly increase from 125,500 in 2020 to 130,000 in 2030 and then remain constant. These numbers imply an initially slightly lower net migration of 50,500 which then increases again to 55,000 in 2030 and in the long term falls to 35,000. In the high migration scenario, the Swiss economy is assumed to continue growing while the European economy stagnates. This leads to an initial increase in immigration to 210,000 in 2030. However, in the longer term the aging societies of the European Union lead to a decrease of immigration to 190'000 in 2050. Due to the higher amount of foreigners, emigration is assumed to increase to 140,000 emigrants per year. In the low migration scenario, a rapid improvement of the economic situation in the EU is assumed, leading to higher competition for labor and a worse economic development in Switzerland. Immigrations reduce to 160,000 by 2030 and 140,000 in 2040. Emigrations are assumed to decrease to 120,000 emigrants per year.

Figure 12 shows how these alternative assumptions affect model outcomes. Differing assumptions concerning fertility only affect model outcomes in the longer term, since it takes at least 20 years for newborns to enter the model as labor. Even in the longer term, i.e. after 2050, they only change the model outcomes marginally. Despite the higher (lower) labor supply with a higher (lower) fertility, GDP per capita is not affected. Capital stock per capita is slightly lower (higher) and contribution rates increase by less (more) because of the higher (lower) amount of workers compared to the unchanged retired population. More interesting is the effect of different migration scenarios. All indicators vary greatly depending on the assumptions concerning migration. A lower net migration would lead to a much more steep decline in GDP per capita, whereas a higher net migration comes close to balancing out the effects of the demographic transition in terms of GDP per capita. However, in terms of households' disposable income, even the high migration scenario shows strong negative effects during the demographic transition. The low migration scenario leads to a near constant supply of labor during the whole observation period. Note that even the low migration scenario still assumes a positive net migration. Should net migration become neutral or even negative, for example due to changing political conditions (e.g. Switzerland leaving the Schengen area), this would lead to a decreasing labor supply in Switzerland and imply severe labor shortages.

6 Conclusion

In order to demonstrate the effects of demographic change on the Swiss labor market and evaluate the consequences of an exogenous increase in participation rates I develop a computable general equilibrium model with overlapping generations. My results show the negative impact of demographic change on the Swiss economy. Especially after 2030, GDP per capita starts decreasing, with wages increasing especially for young and middle-aged workers, and contribution rates to the PAYG pension almost doubling by 2070. I also show that the relative production of health services increases while the relative output of the construction sector decreases due to aging induced shifts in consumption patterns and lower investments.

I proceed to implement different policy reform scenarios and show that even a relatively modest increase in participation rates of women or older workers leads to similar macroeconomic improvements as an increase in the retirement age by two years. This highlights the importance of reducing labor shortages. It is also a recommendation for policy makers to pursue policies that increase the participation rates of women or old workers. Especially with regards to the political feasibility of retirement age reforms, such reforms present a more easily achievable alternative.

It should be noted that there are many possible reforms that might be implemented and are not considered in this paper. Due to the focus on labor market outcomes, the pension and tax systems are not modeled with great detail. Especially alternative financing schemes for the pension (some of which are already implemented, as noted in Section 3), as well as social security and the second and third pillar of the pension system are not considered here. However, the goal of this paper is not finding an ideal policy mix. Instead, I try to evaluate the efficacy of labor market centered policies. In this respect, the relatively simple counterfactual scenario of a statutory retirement age increase is well suited to gauge the importance of the macroeconomic effects of a participation rate increase in comparison. The costs, especially politically, of increasing the retirement age are well understood and therefore suggesting a potentially less costly alternative with similar benefits is important. Of course, an optimal policy response includes other measures as well. Finding this optimal policy mix is left for future research. No matter what policy mix is chosen however, the demographic transition will lead to massive economic and cultural changes that cannot be offset by policy alone.

References

Altig, D., A. J. Auerbach, L. J. Kotlikoff, K. A. Smetters, and J. Walliser (2001). Simulating fundamental tax reform in the united states. *American Economic Review 91*(3), 574–595.

Auerbach, A. J. and L. J. Kotlikoff (1987). *Dynamic fiscal policy.* Cambridge [Cambridgeshire] and New York: Cambridge University Press.

Blanchard, O. J. (1985). Debt, deficits, and finite horizons. *The Journal of Political Economy 93*(2), 223–247.

Börsch-Supan, A. (2003). Labor market effects of population aging. *Labour 17*((Special Issue)), 5–44.

Buchmann, M. (2020). Skilled or unskilled? an occupation-based approach of classifying workers in switzerland. *Working Paper*.

Bütler, M. (2000). The political feasibility of pension reform options: the case of switzerland. *Journal of Public Economics 75*(3), 389–416.

Card, D. and T. Lemieux (2001). Can falling supply explain the rising return to college for younger men? a cohort-based analysis. *The Quarterly Journal of Economics 116*(2), 705–746.

De Nardi, M., S. İmrohoroğlu, and T. J. Sargent (1999). Projected u.s. demographics and social security. *Review of Economic Dynamics 2*(3), 575–615.

Federal Statistical Office (2020). Szenarien zur bevölkerungsentwicklung der schweiz und der kantone 2020-2050. *BFS Aktuell 869-2000.*

Fehr, H., S. Jokisch, M. Kallweit, F. Kindermann, and L. J. Kotlikoff (2013). Generational policy and aging in closed and open dynamic general equilibrium models. In P. Dixon and D. Jorgenson (Eds.), *Handbook of Computable General Equilibrium Modeling*, Volume 1, pp. 1719–1800.

Fougère, M., J. Mercenier, and M. Mérette (2007). A sectoral and occupational analysis of population ageing in canada using a dynamic cge overlapping generations model. *Economic Modelling 24*(4), 690–711.

Hamermesh, D. (2001). Older workers in the coming labor "shortage:" implications of labor demand. *Prepared for a Roundtable on the Demand for Older Workers*.

Hauser, L.-M., C.-H. Schlag, and A. Wolf (2020). Demographic change in switzerland: Impacts on economic growth in an overlapping generations model. *HWWI Research Paper 191.*

Havranek, T., R. Horvath, Z. Irsova, and M. Rusnak (2015). Cross-country heterogeneity in intertemporal substitution. *Journal of International Economics 96*(1), 100–118.

Imrohoroglu, S. (1998). A quantitative analysis of capital income taxation. *International Economic Review 39*(2), 307.

Keuschnigg, C., M. Keuschnigg, and C. Jaag (2011). Aging and the financing of social security in switzerland. *Swiss Journal of Economics and Statistics 147*(2), 181–231.

Kotlikoff, L. J., K. Smetters, and J. Walliser (2007). Mitigating america's demographic dilemma by pre-funding social security. *Journal of Monetary Economics 54*(2), 247–266.

Lisenkova, K., M. Mérette, and R. E. Wright (2013). Population ageing and the labour market: Modelling size and age-specific effects. *Economic Modelling 35*, 981–989.

Magnani, R. and J. Mercenier (2009). On linking microsimulation and computable general equilibrium models using exact aggregation of heterogeneous discrete-choice making agents. *Economic Modelling 26*(3), 560–570.

Martinez, I. Z., E. Saez, and M. Siegenthaler (2018). Intertemporal labor supply substitution? evidence from the swiss income tax holidays. *NBER Working Paper* (24634).

Mérette, M. (2007). Substitution between young and old workers in an ageing context. *Prepared for the International Conference on Policy Modeling, Ecomod 2007*.

Mincer, J. (1958). Investment in human capital and personal income distribution. *Journal of Political Economy 66*(4), 281–302.

Müller, A., R. van Nieuwkoop, and C. Lieb (2003). Analyse der finanzierungsquellen für die ahv: Swissolg – ein overlapping generations model für die schweiz. *Bericht in Rahmen des Forschungsprogramms zur längerfristigen Zukunft der Alterssicherung (IDA ForAlt)* (Forschungsbericht Nr. 11/03).

Müller, A., R. van Nieuwkoop, R. Neuenschwander, F. Vöhringer, H. Fehr, and C. Böhringer (2006). Zukunfts- und wachstumsorientiertes steuersystem (zuwachs): Analyse der effizienz-, verteilungs- und wachstumswirkungen einer steuerreform in der schweiz mit dem berechenbaren allgemeinen gleichgewichtsmodell swissolg. *im Auftrag der Eidgenössischen Steuerverwaltung. Schlussbericht.*.

SFSO (2018). Swiss input-output table 2014.

A Complete List of Model Equations

Producers

$$Y_{s,t} = \frac{1}{1-\alpha_s^I} VA_{s,t} \tag{9}$$

$$P^P(s,t) = (1-\alpha_s^X) P_{s,t}^{VA} + \alpha_s^X P_{s,t}^X \tag{10}$$

$$VA_{s,t} = A_{s,t} K_{s,t}^{\alpha_s^K} L_{s,t}^{1-\alpha_s^K} \tag{11}$$

$$r_t K_{s,t} = \alpha_s^K P_{s,t}^{VA} VA_{s,t} \tag{12}$$

$$W_{s,t} L_{s,t} = (1-\alpha_s^K) VA_{s,t} P_{s,t}^{VA} \tag{13}$$

$$X_{s,t} = \alpha_s^X Y_{s,t} \tag{14}$$

$$Ex_{s,t} = \alpha_s^{Ex} \left(\frac{1}{P_{s,t}^{Ex}}\right)^{\sigma_s^{Ex}} \frac{Y_{s,t}}{aT_s} \left(\alpha_s^{Ex} P_{s,t}^{Ex,1-\sigma_s^{Ex}} + (1-\alpha_s^{Ex}) P_{s,t}^{D,1-\sigma_s^{Ex}}\right)^{\frac{\sigma_s^{Ex}}{1-\sigma_s^{Ex}}} \tag{15}$$

$$Y_{s,t}^D = (1-\alpha_s^{Ex}) \left(\frac{1}{P_{s,t}^D}\right)^{\sigma_s^{Ex}} \frac{Y_{s,t}}{aT_s} \left(\alpha_s^{Ex} P_{s,t}^{Ex,1-\sigma_s^{Ex}} + (1-\alpha_s^{Ex}) P_{s,t}^{D,1-\sigma_s^{Ex}}\right)^{\frac{\sigma_s^{Ex}}{1-\sigma_s^{Ex}}} \tag{16}$$

$$M_{s,t} = \alpha_s^M \left(\frac{1}{P_{s,t}^M}\right)^{\sigma_s^M} \frac{Y_{s,t}^C}{aA_s} \left(\alpha_s^M P_{s,t}^{M,1-\sigma_s^M} + (1-\alpha_s^M) P_{s,t}^{D,1-\sigma_s^M}\right)^{\frac{\sigma_s^M}{1-\sigma_s^M}} \tag{17}$$

$$M_{s,t} = (1-\alpha_s^M) \left(\frac{1}{P_{s,t}^D}\right)^{\sigma_s^M} \frac{Y_{s,t}^C}{aA_s} \left(\alpha_s^M P_{s,t}^{M,1-\sigma_s^M} + (1-\alpha_s^M) P_{s,t}^{D,1-\sigma_s^M}\right)^{\frac{\sigma_s^M}{1-\sigma_s^M}} \tag{18}$$

$$P_{s,t} = \left(\alpha_s^M P_{s,t}^{M,1-\sigma_s^M} + (1-\alpha_s^{M,1-\sigma_s^M}) P_{s,t}^D\right)^{\frac{1}{1-\sigma_s^M}} \tag{19}$$

$$P_{s,t}^P = \left(\alpha_s^{Ex} P_{s,t}^{Ex,1-\sigma_s^{Ex}} + (1-\alpha_s^{Ex}) P_s^{D,1-\sigma_{s,t}^{Ex}}\right)^{\frac{1}{1-\sigma_s^{Ex}}} \tag{20}$$

$$P_{s,t}^{Ex} = P0_s^{Ex} ER_t \tag{21}$$

$$P_{s,t}^M = (1+\mathbb{T}_{s,t}) ER_t P0_s^M \tag{22}$$

$$\sum_s P^M_{s,t} M_{s,t} = \sum_s P^{Ex}_{s,t} Ex_{s,t} + NFI_t \tag{23}$$

$$W^{1-\sigma^Q_s}_{s,t} = \sum_q \alpha^Q_{s,q,t} w^{Q,1-\sigma^Q_s}_{s,q,t} \tag{24}$$

$$L^Q_{s,q,t} = \alpha^Q_{s,q,t} \left(\frac{W_{s,t}}{w^Q_{s,q,t}} \right)^{\sigma^Q_s} L_{s,t} \tag{25}$$

$$w^{Q,1-\sigma^A_s}_{s,q,t} = \sum_a \alpha^A_{s,q,a} w^{A,1-\sigma^A_s}_{s,q,a,t} \tag{26}$$

$$L^{AQ}_{s,q,a,t} = \alpha^A_{s,q,a} \left(\frac{w^Q_{s,q,t}}{w^A_{s,q,a,t}} \right)^{\sigma^A_s} L^Q_{s,q,t} \tag{27}$$

$$X^I_{\bar{s},s,t} = \alpha^{XS}_{\bar{s},s,t} X_{s,t} \tag{28}$$

Consumers

$$\psi_{q,g,t} = w_{q,a,t} \xi_{q,a,t} \varepsilon_{q,g,t} (1 - \ell_{q,g,t}), \tag{29}$$

$$P^C_{q,t,g}(1+\tau^C) C_{q,t,g} + B_{q,t+1,g+1} = (1 - \tau^W_t - CTR_t)\psi_{q,g,t} + (1 + i_t - \tau^K i_t)(B_{q,t,g} + \mathcal{U}_{q,t}) + \mathcal{P}_{q,t,g}, \tag{30}$$

$$\mathcal{U}_{q,t} = \frac{\sum_g (1 - SR_{g-1,t-1}) PopQ_{q,t-1,g-1} B_{q,t,g}}{\sum_g PopQ_{q,t-1,g-1}} \tag{31}$$

$$\frac{C_{q,t+1,g+1}}{C_{q,t,g}} = \left(\frac{SR_{g,t}}{1 - SR_{g,t}} \frac{(1 + r_{t+1} - \tau^K_{t+1} r_{t+1}) P^C_{q,t,g}}{\gamma P^C_{q,t+1,g+1}} \frac{1 + \tau^C_t}{1 + \tau^C_{t+1}} \right)^\rho \frac{VV_{q,t+1,g+1}}{VV_{q,t,g}} \tag{32}$$

$$VV_{q,t,g} = \left(1 + \alpha^\theta_{q,t,g} \left[(1 + \tau^W_t - CTR_t)\psi_{q,g,t} + \mu_{q,t,g} \right]^{1-\theta} \right)^{\frac{\theta - \rho}{1 - \theta}} \tag{33}$$

$$C_{q,T,g} = C_{q,T-1,g} \tag{34}$$

$$\frac{\ell_{q,t,g}}{C_{q,t,g}} = \left(\frac{\alpha_{q,t,g}}{(1 - \tau_t^W - CTR_t)(\psi_{q,t,g} + \mu_{q,t,g})} \right)^{\theta} \tag{35}$$

$$\mu_{q,t,g} = \mu_{q,t,g} \ell_{q,t,g} \tag{36}$$

$$P_{q,t,g}^{C,1-\sigma^C} = \sum_s \alpha_{s,g,q}^C P_{s,t}^{1-\sigma^C} \tag{37}$$

$$C_{s,q,g,t}^S = \alpha_{s,g,q}^C \left(\frac{P_{q,t,g}^C}{P_{s,t}} \right)^{\sigma^C} C_{q,t,g} \tag{38}$$

$$LS_{q,a,t} = PopQ_{q,t,g} \xi_{q,a,t} \varepsilon_{q,g,t} (1 - \ell_{q,g,t}) \tag{39}$$

$$w_{q,a,t}^{1+\sigma_q^L} = \sum_s \alpha_{a,s,q}^S w_{s,q,a,t}^{A,1+\sigma_q^S} \tag{40}$$

$$LSS_{s,q,a,t} = \alpha_{a,s,q}^S \left(\frac{w_{s,q,a,t}^A}{w_{q,a,t}} \right)^{\sigma_q^S} LS_{q,a,t} \tag{41}$$

Capital, Government and other Markets

$$P_t^{I,1-\sigma^I} = \sum_s \alpha_s^I P_{s,t}^{1-\sigma^I} \tag{42}$$

$$I_{s,t}^S = \alpha_s^I \left(\frac{P_t^I}{P_{s,t}} \right)^{\sigma^I} I_t \tag{43}$$

$$1 + i_t = \frac{r_t + (1-\delta) P_t^I}{P_{t-1}^I} \tag{44}$$

$$KS_{t+1} = I_t + (1-\delta) KS_t \tag{45}$$

$$I_t = ((n_t - 1) + \delta) KS_t \tag{46}$$

$$P_t^G \mathcal{B}_{t+1} + \sum_q \sum_g PopQ_{q,t,g} \left(\tau_t^W \psi_{q,t,g} + \tau_t^C P_{q,t,g}^C C_{q,t,g} + \tau_t^K i_t (B_{q,t,g} + \mathcal{U}_{q,t,g}) \right)$$
$$+ \sum_s M_{s,t} \mathbb{T}_{s,t} ER_t P0_s^M = P_t^G G_t + (1+i_t) \frac{P_t^G}{P_{t-1}^G} P_{t-1}^G \mathcal{B}_t \tag{47}$$

$$n_T P_T^G \mathcal{B}_T + \sum_q \sum_g PopQ_{q,T,g} \left(\tau_T^W \psi_{q,T,g} + \tau_T^C P_{q,T,g}^C C_{q,T,g} + \tau_T^K i_T (B_{q,T,g} + \mathcal{U}_{q,T,g}) \right)$$
$$+ \sum_s M_{s,T} \mathbb{T}_{s,T} ER_T P0_s^M = P_T^G G_T + (1+i_{T-1}) P_T^G \mathcal{B}_T \tag{48}$$

$$P_t^G \mathcal{B}_{t+1} = n_t P_{t-1}^G \mathcal{B}_t \tag{49}$$

$$P_t^{G,1-\sigma^G} = \sum_s \alpha_s^G P_{s,t}^{1-\sigma^G} \tag{50}$$

$$G_{s,t}^S = \alpha_s^G \left(\frac{P_t^G}{P_{s,t}} \right)^{\sigma^G} G_t \tag{51}$$

$$\mathcal{P}_{q,t,gr} = PR \frac{1}{45} \sum_{g=1}^{45} \psi_{q,t+gr-g,g} \tag{52}$$

$$CTR_t = \frac{\sum_q \sum_{gr} PopQ_{q,t,gr} \mathcal{P}_{q,t,gr}}{\sum_q \sum_g PopQ_{q,t,g} \psi_{q,t,g}} \tag{53}$$

$$Y_{s,t} - Ex_{s,t} + M_{s,t} = \sum_q \sum_g PopQ_{q,t,g} C_{s,q,t,g}^S + I_{s,t}^S + G_{s,t}^S + \sum_{\bar{s}} S_{s,\bar{s},t}^I \tag{54}$$

$$LSS_{s,q,a,t} = L_{s,q,a,t}^{AQ} \tag{55}$$

$$\alpha^{KS0} KS_t = \sum_s K_{s,t} \tag{56}$$

$$\sum_g \sum_q PopQ_{q,t+1,g+1} (B_{q,t+1,g+1} + \mathcal{U}_{q,t+1,g+1}) = P_t^I KS_{t+1} + P_t^G \mathcal{B}_{t+1} \tag{57}$$

B Additional Tables

Table 9: Sector aggregates

Sector	NOGA Sections	Code
Agriculture	Agriculture, Forestry and Fishing	A
	Mining and Quarrying	B
Manufacturing	Manufacturing	C
	Electricity, Gas, Steam and Air Conditioning Supply	D
	Water Supply; Sewerage, Waste Management and Remediation Activities	E
Construction	Construction	F
Trade & Transport	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	G
	Transportation and Storage	H
IT	Information and Communication	J
Finance	Financial and Insurance Activities	K
	Real Estate Activities	L
	Professional, Scientific and Technical Activities	M
Health	Human Health and Social Work Activities	Q
Other Services	Accommodation and Food Service Activities	I
	Administrative and Support Service Activities	N
	Public Administration and Defence; Compulsory Social Security	O
	Education	P
	Arts, Entertainment and Recreation	R
	Other Service Activities	S

C Additional Results

Table 13: Sectoral Impact of Population Aging with retirement age increase

	2020	2030	2040	2050	2060	2070
Manufacturing	29.83	29.85	29.71	29.64	29.58	29.53
Finance	20.83	21.12	21.30	21.38	21.43	21.41
Construction	6.81	6.62	6.37	6.21	6.11	6.05
Trade and Transport	18.40	18.46	18.55	18.62	18.67	18.70
IT	4.39	4.37	4.32	4.28	4.25	4.22
Other Services	12.75	12.62	12.69	12.76	12.81	12.87
Health	5.95	5.95	6.05	6.12	6.15	6.20
Agriculture	1.04	1.02	1.01	1.01	1.01	1.01

Shares of sectoral output relative to aggregate output, in %.

Figure 13: Participation rates of affected households before and after retirement age increase

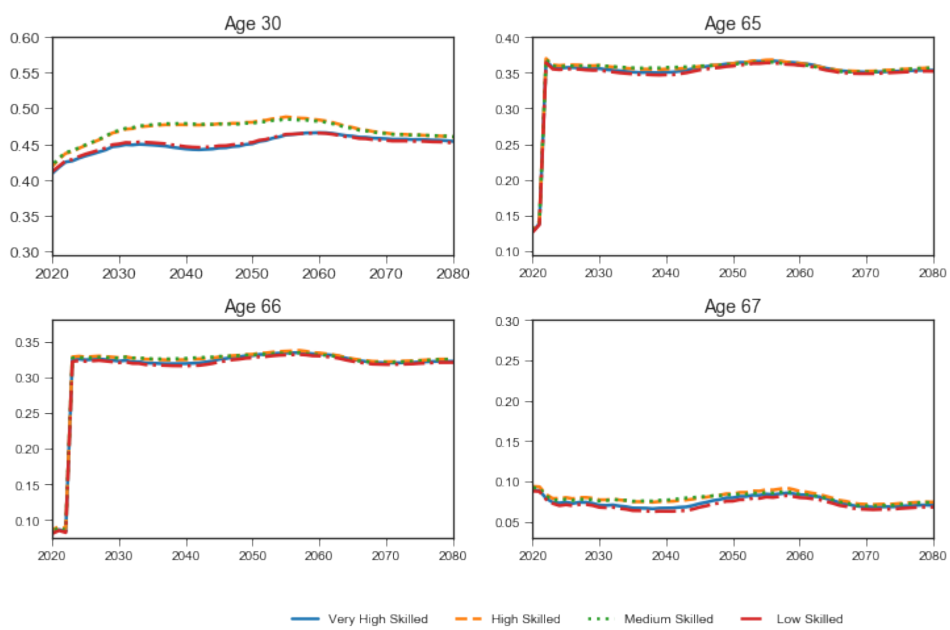


Table 10: Wages during the demographic transition

		20-34			35-49			50-64			65-79		
		2030	2045	2060	2030	2045	2060	2030	2045	2060	2030	2045	2060
Skill 1	Manufacturing	1.061	1.087	1.096	1.027	1.053	1.066	1.035	1.027	1.036	0.989	0.989	0.970
	Finance	1.065	1.097	1.109	1.031	1.062	1.078	1.040	1.036	1.048	0.993	0.998	0.981
	Construction	1.052	1.058	1.053	1.017	1.024	1.024	1.026	0.999	0.995	0.980	0.962	0.931
	Trade and Transport	1.069	1.103	1.117	1.035	1.068	1.086	1.043	1.042	1.056	0.997	1.003	0.988
	IT	1.049	1.065	1.070	1.015	1.031	1.041	1.024	1.006	1.012	0.978	0.969	0.947
	Other Services	1.065	1.098	1.116	1.030	1.063	1.085	1.039	1.037	1.055	0.993	0.999	0.988
	Health	1.082	1.132	1.152	1.047	1.096	1.120	1.056	1.069	1.089	1.008	1.029	1.019
	Agriculture	1.060	1.086	1.097	1.026	1.051	1.067	1.035	1.025	1.038	0.988	0.987	0.971
Skill 2	Manufacturing	1.093	1.119	1.124	1.091	1.141	1.143	1.068	1.113	1.136	0.992	1.007	1.030
	Finance	1.097	1.128	1.136	1.095	1.150	1.155	1.071	1.123	1.148	0.995	1.015	1.041
	Construction	1.084	1.090	1.082	1.081	1.111	1.100	1.058	1.085	1.093	0.983	0.981	0.991
	Trade and Transport	1.101	1.134	1.145	1.099	1.156	1.164	1.075	1.129	1.156	0.999	1.021	1.049
	IT	1.080	1.095	1.097	1.078	1.116	1.115	1.055	1.089	1.108	0.980	0.985	1.005
	Other Services	1.096	1.131	1.146	1.094	1.153	1.165	1.071	1.125	1.158	0.995	1.017	1.050
	Health	1.113	1.164	1.181	1.111	1.186	1.200	1.087	1.158	1.193	1.010	1.047	1.082
	Agriculture	1.089	1.116	1.126	1.087	1.138	1.145	1.064	1.111	1.138	0.988	1.004	1.032
Skill 3	Manufacturing	1.088	1.112	1.117	1.082	1.127	1.130	1.062	1.099	1.120	0.992	1.001	1.023
	Finance	1.092	1.121	1.129	1.086	1.136	1.142	1.066	1.109	1.132	0.996	1.009	1.034
	Construction	1.079	1.083	1.074	1.073	1.098	1.087	1.054	1.072	1.077	0.984	0.976	0.984
	Trade and Transport	1.096	1.128	1.137	1.090	1.143	1.151	1.070	1.115	1.141	1.000	1.016	1.042
	IT	1.076	1.089	1.090	1.070	1.104	1.104	1.051	1.078	1.094	0.982	0.981	0.999
	Other Services	1.091	1.123	1.138	1.085	1.139	1.152	1.066	1.111	1.141	0.996	1.012	1.042
	Health	1.108	1.156	1.173	1.102	1.172	1.187	1.082	1.143	1.176	1.011	1.041	1.074
	Agriculture	1.086	1.110	1.118	1.080	1.124	1.132	1.060	1.097	1.122	0.990	0.999	1.024
Skill4	Manufacturing	1.068	1.093	1.100	1.040	1.070	1.080	1.043	1.045	1.056	0.991	0.997	0.988
	Finance	1.071	1.102	1.112	1.043	1.079	1.092	1.046	1.053	1.068	0.994	1.006	0.998
	Construction	1.058	1.064	1.058	1.031	1.042	1.039	1.033	1.017	1.016	0.982	0.971	0.950
	Trade and Transport	1.076	1.108	1.120	1.048	1.085	1.100	1.051	1.059	1.075	0.998	1.011	1.005
	IT	1.053	1.067	1.069	1.026	1.045	1.050	1.029	1.020	1.027	0.977	0.974	0.960
	Other Services	1.070	1.103	1.120	1.043	1.080	1.100	1.046	1.055	1.075	0.993	1.007	1.005
	Health	1.087	1.135	1.154	1.058	1.111	1.133	1.061	1.085	1.108	1.008	1.036	1.036
	Agriculture	1.065	1.091	1.101	1.038	1.068	1.081	1.041	1.043	1.057	0.988	0.995	0.988

Note: Changes in wage rates relative to 2020. Skill 1 represents the highest qualification level, Skill 4 represents the lowest qualification level.

Table 11: Sectoral Impact of Population Aging with old workers participation rate increase

	2020	2030	2040	2050	2060	2070
Manufacturing	29.81	29.83	29.68	29.60	29.53	29.48
Finance	20.82	21.05	21.23	21.30	21.35	21.32
Construction	6.79	6.61	6.34	6.18	6.06	6.00
Trade and Transport	18.42	18.48	18.58	18.65	18.71	18.74
IT	4.38	4.37	4.31	4.27	4.24	4.21
Other Services	12.78	12.66	12.74	12.82	12.88	12.96
Health	5.97	5.99	6.11	6.18	6.22	6.28
Agriculture	1.03	1.02	1.01	1.01	1.01	1.01

Shares of sectoral output relative to aggregate output, in %.

Figure 14: Participation rates of affected households before and after women's participation rate increase

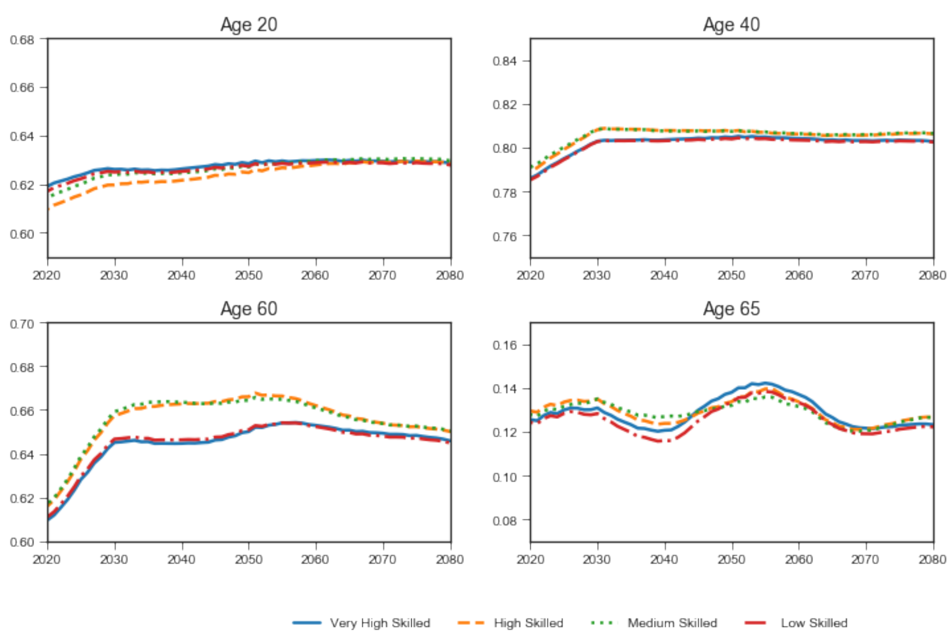


Table 12: Wages with increase of old workers participation rates

		20-34			35-49			50-64			65-79		
		2030	2045	2060	2030	2045	2060	2030	2045	2060	2030	2045	2060
Skill 1	Manufacturing	1.056	1.086	1.098	1.022	1.052	1.067	1.014	1.010	1.021	0.988	0.994	0.975
	Finance	1.060	1.097	1.111	1.026	1.062	1.080	1.018	1.019	1.033	0.992	1.004	0.987
	Construction	1.048	1.058	1.055	1.014	1.024	1.025	1.006	0.983	0.981	0.981	0.968	0.937
	Trade and Transport	1.063	1.102	1.118	1.029	1.067	1.087	1.021	1.024	1.040	0.995	1.009	0.994
	IT	1.045	1.065	1.072	1.011	1.031	1.043	1.003	0.990	0.998	0.978	0.975	0.953
	Other Services	1.056	1.093	1.113	1.021	1.058	1.082	1.014	1.016	1.035	0.988	1.000	0.989
	Health	1.074	1.129	1.152	1.039	1.093	1.120	1.031	1.049	1.071	1.005	1.033	1.023
	Agriculture	1.051	1.081	1.096	1.017	1.047	1.065	1.009	1.005	1.019	0.984	0.990	0.974
Skill 2	Manufacturing	1.088	1.118	1.127	1.086	1.140	1.145	1.046	1.096	1.120	0.990	1.012	1.036
	Finance	1.091	1.128	1.139	1.089	1.149	1.158	1.049	1.105	1.133	0.994	1.020	1.047
	Construction	1.081	1.092	1.085	1.079	1.113	1.103	1.039	1.070	1.079	0.984	0.987	0.998
	Trade and Transport	1.096	1.134	1.147	1.093	1.155	1.166	1.053	1.111	1.141	0.997	1.025	1.055
	IT	1.076	1.095	1.099	1.073	1.116	1.117	1.034	1.073	1.093	0.979	0.990	1.011
	Other Services	1.087	1.126	1.143	1.085	1.148	1.162	1.045	1.103	1.137	0.990	1.018	1.051
	Health	1.105	1.161	1.181	1.103	1.183	1.201	1.063	1.138	1.175	1.006	1.050	1.086
	Agriculture	1.079	1.111	1.124	1.077	1.133	1.143	1.037	1.089	1.118	0.983	1.005	1.034
Skill 3	Manufacturing	1.083	1.111	1.118	1.076	1.126	1.132	1.040	1.082	1.104	0.991	1.006	1.028
	Finance	1.086	1.120	1.131	1.080	1.135	1.144	1.044	1.091	1.117	0.994	1.014	1.040
	Construction	1.077	1.085	1.078	1.071	1.099	1.091	1.035	1.057	1.064	0.986	0.982	0.991
	Trade and Transport	1.090	1.127	1.139	1.084	1.142	1.153	1.048	1.098	1.125	0.998	1.020	1.047
	IT	1.072	1.090	1.093	1.066	1.104	1.106	1.030	1.061	1.079	0.981	0.987	1.005
	Other Services	1.083	1.119	1.135	1.076	1.134	1.149	1.040	1.090	1.121	0.991	1.013	1.044
	Health	1.100	1.153	1.173	1.094	1.169	1.187	1.057	1.124	1.158	1.007	1.044	1.078
	Agriculture	1.077	1.106	1.117	1.071	1.120	1.130	1.035	1.077	1.103	0.986	1.001	1.027
Skill4	Manufacturing	1.063	1.092	1.102	1.035	1.069	1.082	1.021	1.028	1.041	0.990	1.003	0.994
	Finance	1.066	1.101	1.114	1.038	1.078	1.094	1.024	1.036	1.052	0.993	1.011	1.005
	Construction	1.055	1.065	1.061	1.028	1.043	1.042	1.014	1.002	1.002	0.983	0.978	0.957
	Trade and Transport	1.070	1.107	1.122	1.042	1.084	1.101	1.028	1.042	1.059	0.997	1.017	1.011
	IT	1.050	1.067	1.072	1.022	1.045	1.053	1.009	1.004	1.013	0.978	0.980	0.967
	Other Services	1.061	1.098	1.117	1.034	1.075	1.097	1.020	1.033	1.055	0.989	1.008	1.007
	Health	1.079	1.132	1.154	1.051	1.108	1.133	1.037	1.065	1.090	1.005	1.040	1.040
	Agriculture	1.057	1.087	1.100	1.030	1.064	1.080	1.016	1.023	1.039	0.985	0.998	0.992

Note: Changes in wage rates relative to 2020. Skill 1 represents the highest qualification level, Skill 4 represents the lowest qualification level.

Table 14: Wages with increase retirement age

		20-34			35-49			50-64			65-79		
		2030	2045	2060	2030	2045	2060	2030	2045	2060	2030	2045	2060
Skill 1	Manufacturing	1.062	1.094	1.108	1.027	1.059	1.077	1.034	1.031	1.045	0.933	0.941	0.920
	Finance	1.065	1.104	1.120	1.030	1.069	1.089	1.038	1.040	1.057	0.937	0.950	0.930
	Construction	1.054	1.067	1.068	1.020	1.033	1.038	1.027	1.006	1.007	0.927	0.918	0.886
	Trade and Transport	1.069	1.110	1.128	1.034	1.074	1.096	1.042	1.046	1.064	0.940	0.954	0.936
	IT	1.051	1.073	1.083	1.016	1.039	1.053	1.024	1.011	1.022	0.924	0.923	0.899
	Other Services	1.062	1.102	1.123	1.028	1.066	1.092	1.035	1.038	1.059	0.934	0.948	0.932
	Health	1.080	1.135	1.159	1.044	1.099	1.127	1.052	1.070	1.094	0.949	0.977	0.963
	Agriculture	1.060	1.093	1.109	1.025	1.058	1.078	1.033	1.030	1.047	0.932	0.940	0.921
Skill 2	Manufacturing	1.094	1.127	1.137	1.091	1.148	1.156	1.067	1.119	1.146	0.938	0.961	0.980
	Finance	1.097	1.135	1.149	1.094	1.157	1.167	1.070	1.127	1.158	0.940	0.969	0.990
	Construction	1.086	1.100	1.097	1.084	1.121	1.115	1.059	1.093	1.106	0.931	0.939	0.945
	Trade and Transport	1.101	1.141	1.156	1.099	1.163	1.175	1.074	1.133	1.166	0.944	0.973	0.996
	IT	1.082	1.103	1.110	1.079	1.124	1.129	1.055	1.096	1.120	0.927	0.941	0.957
	Other Services	1.094	1.134	1.153	1.091	1.156	1.172	1.067	1.127	1.163	0.938	0.968	0.994
	Health	1.111	1.168	1.189	1.109	1.190	1.209	1.084	1.160	1.199	0.953	0.996	1.025
	Agriculture	1.089	1.123	1.138	1.086	1.144	1.157	1.061	1.115	1.148	0.933	0.958	0.981
Skill 3	Manufacturing	1.089	1.119	1.129	1.082	1.134	1.142	1.061	1.105	1.130	0.938	0.956	0.972
	Finance	1.092	1.128	1.141	1.085	1.143	1.154	1.064	1.113	1.142	0.941	0.963	0.982
	Construction	1.082	1.094	1.090	1.075	1.108	1.103	1.055	1.080	1.091	0.932	0.934	0.938
	Trade and Transport	1.096	1.134	1.149	1.090	1.149	1.162	1.068	1.120	1.150	0.944	0.969	0.989
	IT	1.078	1.098	1.104	1.071	1.112	1.117	1.051	1.084	1.105	0.929	0.938	0.950
	Other Services	1.089	1.127	1.146	1.083	1.142	1.159	1.062	1.113	1.146	0.938	0.962	0.986
	Health	1.106	1.160	1.181	1.099	1.175	1.195	1.078	1.145	1.182	0.953	0.991	1.016
	Agriculture	1.086	1.117	1.131	1.079	1.131	1.144	1.058	1.102	1.131	0.935	0.954	0.973
Skill4	Manufacturing	1.068	1.100	1.112	1.040	1.077	1.092	1.042	1.049	1.065	0.936	0.950	0.938
	Finance	1.071	1.108	1.123	1.043	1.085	1.103	1.044	1.058	1.076	0.938	0.958	0.947
	Construction	1.061	1.074	1.073	1.033	1.051	1.053	1.034	1.025	1.028	0.929	0.928	0.905
	Trade and Transport	1.075	1.114	1.130	1.047	1.090	1.110	1.048	1.063	1.083	0.942	0.962	0.953
	IT	1.051	1.072	1.078	1.024	1.049	1.059	1.025	1.023	1.033	0.921	0.926	0.909
	Other Services	1.068	1.106	1.126	1.040	1.083	1.106	1.041	1.055	1.079	0.935	0.956	0.950
	Health	1.085	1.139	1.161	1.056	1.115	1.140	1.058	1.087	1.113	0.950	0.984	0.979
	Agriculture	1.064	1.097	1.112	1.036	1.073	1.092	1.038	1.046	1.065	0.932	0.948	0.938

Note: Changes in wage rates relative to 2020. Skill 1 represents the highest qualification level, Skill 4 represents the lowest qualification level.

Table 15: Sectoral Impact of Population Aging with women's participation rate increase

	2020	2030	2040	2050	2060	2070
Manufacturing	29.81	29.83	29.69	29.60	29.54	29.48
Finance	20.82	21.07	21.25	21.32	21.37	21.34
Construction	6.79	6.61	6.34	6.18	6.07	6.01
Trade and Transport	18.41	18.47	18.57	18.64	18.70	18.73
IT	4.38	4.37	4.31	4.27	4.24	4.21
Other Services	12.77	12.65	12.73	12.81	12.87	12.95
Health	5.97	5.98	6.09	6.17	6.20	6.26
Agriculture	1.03	1.02	1.01	1.01	1.01	1.01

Shares of sectoral output relative to aggregate output, in %.

Table 16: Wages with women's participation rate increase

		20-34			35-49			50-64			65-79		
		2030	2045	2060	2030	2045	2060	2030	2045	2060	2030	2045	2060
	Manufacturing	1.054	1.085	1.096	1.019	1.049	1.064	1.025	1.021	1.033	0.988	0.991	0.973
	Finance	1.058	1.095	1.109	1.022	1.058	1.077	1.029	1.030	1.045	0.991	1.000	0.984
	Construction	1.047	1.057	1.054	1.011	1.022	1.024	1.018	0.994	0.993	0.981	0.965	0.935
Skill 1	Trade and Transport	1.062	1.101	1.117	1.026	1.064	1.084	1.033	1.036	1.052	0.995	1.005	0.991
	IT	1.043	1.063	1.071	1.008	1.028	1.040	1.015	1.001	1.009	0.977	0.971	0.950
	Other Services	1.056	1.093	1.113	1.020	1.057	1.081	1.027	1.029	1.049	0.989	0.998	0.988
	Health	1.073	1.128	1.150	1.037	1.090	1.117	1.044	1.061	1.084	1.005	1.030	1.021
	Agriculture	1.053	1.083	1.097	1.017	1.047	1.065	1.024	1.019	1.034	0.986	0.988	0.974
	Manufacturing	1.087	1.117	1.125	1.083	1.137	1.142	1.058	1.108	1.133	0.990	1.008	1.033
	Finance	1.090	1.126	1.137	1.086	1.146	1.154	1.061	1.116	1.145	0.993	1.016	1.044
	Construction	1.079	1.090	1.084	1.075	1.109	1.100	1.050	1.081	1.091	0.983	0.984	0.995
Skill 2	Trade and Transport	1.094	1.132	1.145	1.090	1.152	1.163	1.065	1.123	1.153	0.997	1.022	1.052
	IT	1.074	1.093	1.098	1.071	1.113	1.115	1.046	1.084	1.106	0.979	0.987	1.008
	Other Services	1.087	1.126	1.143	1.083	1.146	1.161	1.058	1.116	1.151	0.991	1.016	1.050
	Health	1.105	1.160	1.180	1.101	1.181	1.198	1.075	1.150	1.188	1.007	1.047	1.083
	Agriculture	1.081	1.113	1.126	1.078	1.133	1.143	1.052	1.104	1.134	0.985	1.005	1.034
	Manufacturing	1.082	1.110	1.117	1.074	1.123	1.129	1.052	1.094	1.117	0.991	1.003	1.026
	Finance	1.085	1.119	1.129	1.077	1.132	1.141	1.056	1.103	1.129	0.994	1.011	1.036
	Construction	1.075	1.083	1.076	1.067	1.096	1.088	1.046	1.068	1.076	0.985	0.979	0.988
Skill 3	Trade and Transport	1.089	1.125	1.138	1.081	1.139	1.150	1.060	1.109	1.137	0.998	1.017	1.044
	IT	1.070	1.088	1.092	1.063	1.101	1.103	1.041	1.072	1.091	0.980	0.983	1.002
	Other Services	1.083	1.119	1.135	1.075	1.132	1.147	1.053	1.103	1.135	0.992	1.011	1.042
	Health	1.100	1.152	1.172	1.092	1.166	1.184	1.070	1.136	1.171	1.007	1.041	1.075
	Agriculture	1.078	1.107	1.118	1.071	1.120	1.130	1.049	1.091	1.118	0.988	1.000	1.026
	Manufacturing	1.061	1.090	1.100	1.032	1.066	1.079	1.033	1.039	1.053	0.989	0.999	0.991
	Finance	1.064	1.099	1.112	1.035	1.075	1.091	1.036	1.047	1.064	0.992	1.007	1.001
	Construction	1.053	1.064	1.060	1.025	1.040	1.039	1.025	1.013	1.014	0.982	0.974	0.954
Skill4	Trade and Transport	1.069	1.106	1.120	1.039	1.081	1.099	1.040	1.053	1.072	0.996	1.013	1.008
	IT	1.048	1.066	1.071	1.019	1.042	1.050	1.020	1.015	1.024	0.977	0.976	0.964
	Other Services	1.061	1.098	1.117	1.032	1.073	1.095	1.033	1.046	1.068	0.989	1.006	1.006
	Health	1.078	1.131	1.152	1.049	1.106	1.130	1.049	1.078	1.103	1.005	1.036	1.038
	Agriculture	1.058	1.088	1.101	1.029	1.063	1.080	1.030	1.036	1.053	0.986	0.997	0.991

Note: Changes in wage rates relative to 2020. Skill 1 represents the highest qualification level, Skill 4 represents the lowest qualification level.

Figure 15: Macroeconomic changes with different elasticities of transformation between sectoral employment

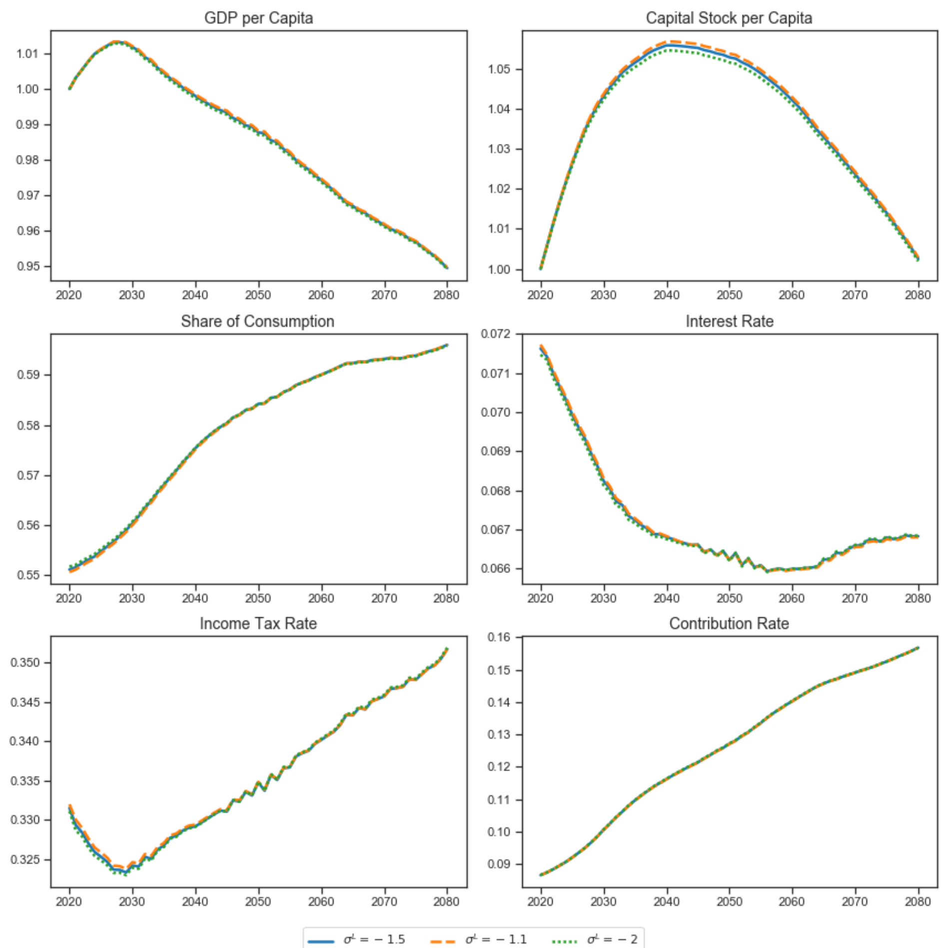


Figure 16: Sectoral changes with different elasticities of transformation between sectoral employment